Bulletin 116

DEPARTMENT OF THE INTERIOR

FRANKLIN K. LANE, SECRETARY

BUREAU OF MINES

VAN. H. MANNING, DIRECTOR

METHODS OF SAMPLING DELIVERED COAL

AND SPECIFICATIONS FOR THE PURCHASE OF COAL FOR THE GOVERNMENT

BY

GEORGE S. POPE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

Collected set.

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METHODS OF SAMPLING DELIVERED COAL, AND TYPES OF SPECIFICATIONS FOR THE PURCHASE OF COAL FOR THE GOVERNMENT.

By George S. Pope.

INTRODUCTION.

This bulletin is a revision of Bulletin 63 and is published by the Bureau of Mines in order that purchasers of coal for Government, State, municipal, or private use may be informed regarding advances or refinements in sampling coal deliveries and preparing specifications for the purchase of coal.

The purchase of coal by the Government under specifications depending on the heating value of the coal, its content of ash and of moisture, and other considerations, rather than upon the reputation or trade name of the coal, was based on the fuel investigations begun by the Technologic Branch of the United States Geological Survey in 1904. The plan was first adopted by the Treasury Department in 1906. Since then the plan, variously modified in form, but the same in principle, has been gradually adopted by other departments until, at present, of the coal used by the Government, the total value of which approximates $8,000,000 annually, more than half is purchased under specifications. The Government publications dealing with the adoption by the Government of the specification plan, the number of contracts awarded on that basis, and the quality of the coal delivered under such contracts in the several fiscal years covered by the reports are given in publications [a] listed at the end of this bulletin.

Under the authority of acts of Congress making appropriations for analyzing and testing fuels belonging to or for the use of the United States Government, a laboratory is maintained at the headquarters of the Bureau of Mines, Washington, D. C., where samples representing deliveries of coal purchased under specifications for Government use are analyzed and tested.

At this laboratory more than 1,200 samples have been analyzed and tested in one month. With the complete equipment and the efficient force employed, the analytical work has been so perfected that the analyses and heating-value tests of the samples received are as accurate as may be reasonably expected in laboratory work of this nature.

[a] See Bulls. 11, 41, and 119, Bureau of Mines.

One of the serious drawbacks to the general adoption of the specification method for the purchase of coal is the difficulty of obtaining at reasonable cost samples of coal that can be considered fairly representative of the commercial product delivered in wagons, railroad cars, or ships. Therefore the method of taking and preparing samples for shipment to the laboratory has been given fully as much care as the making of the analyses and tests, and a general plan of collecting samples fairly representative of the delivered coal has been evolved through various modifications and improvements based on experience and increased knowledge of the physical and chemical characteristics of the various coals that are purchased by the Government. The method that is in general use by the Government is described in the following pages.

In connection with studies of the coal deposits of the country, of the best methods of preventing waste in mining, and of increasing efficiency in the utilization of coal belonging to or for the use of the Government, geologists and engineers of the United States Geological Survey and of the Bureau of Mines have visited more than 2,500 coal mines scattered through all of the coal-producing States and Territories. From each mine 2 to 8 or more samples were taken, the number depending upon the size of the mine and its output. The analyses and descriptions of the samples collected up to the end of the fiscal year 1913 are published in Bulletins 22[a] and 85,[b] Bureau of Mines, and those of samples collected in the fiscal years 1914 and 1915 are presented in Bulletin 123.[c]

A study of the analyses of these samples and of the samples taken from cars shipped from a number of the same mines shows that the mine samples are as a rule of higher grade than the average commercial shipments, particularly with respect to containing a lower percentage of ash and having a correspondingly higher heating value. This difference is due to the fact that the Government inspector, proceeding on the basis of what can be done by a good miner, usually removes more of the partings of bone, slate, and other extraneous matter from his mine samples than the average miner does in ordinary practice, the aim of the miner being to get the maximum number of tons past the tipple inspection, as his earnings are based on his output. The average miner, therefore, does not always take as much care as he might in rejecting the impurities. The difference may be caused, too, by the presence of pieces of the mine roof and floor in commercial shipments. The Government inspector can readily

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[a] Lord, N. W., and others, Analyses of coals in the United States, with descriptions of mine and field samples collected between July 1, 1904, and June 30, 1910: Bull. 22, Bureau of Mines, 1912, 1129 pp. In two parts.

[b] Fieldner, A. C., Smith, H. I., Fay, A. H., and Sanford, S., Analyses of mine and car samples of coal collected in the fiscal years 1911 to 1913: Bull. 85, Bureau of Mines, 1914, 444 pp.

[c] Fieldner, A. C., Smith, H. I., Paul, J. W., and Sanford, S., Analyses of mine and car samples of coal collected in the fiscal years 1914 to 1916: Bull. 123, Bureau of Mines, 1918, 478 pp.

exclude these from the mine sample, but they often get into the commercial coal as a result of the character of the roof and floor and of the mining methods employed. The efficiency of the tipple inspection and the means employed in rejecting impurities when the coal is loaded into the railroad car are also factors that often largely account for the difference between mine and commercial samples. Most of the samples collected from the mines by the Government inspectors show a higher moisture content than commercial samples, because of the generally moist atmosphere of the mine and the precaution taken to prevent loss of moisture in the collection, preparation, and analysis of mine samples.

When properly taken, the mine samples are of great value, as they indicate the general character of the coal and the uniformity of the coal bed and enable one to determine its probable value for any designated purpose, provided due consideration is given to the character of the partings, the roof, and the floor, and to the possibility of pieces from these being loaded with the commercial output.

The collection of mine samples by the Bureau of Mines and the Geological Survey is done in a systematic manner, according to a prearranged plan, and the same procedure is always followed where circumstances permit. A special outfit for use in collecting mine samples has been developed. The method followed and a description, with illustrations, of the outfit are published in Bureau of Mines Technical Paper 1, entitled "The Sampling of Coal in the Mine."

THEORY OF SAMPLING.

To determine with utmost accuracy the ash content and heating value of a quantity of delivered coal would require the burning of the entire quantity, and special apparatus arranged to measure the total heat liberated, or would require crushing the whole quantity, and reducing it by an elaborate scheme of successive crushings, mixings, and fractional selections to portions weighing approximately 1 gram, the minute quantity which the chemist requires for each determination. Either of these procedures is obviously impracticable if the coal is to be used for the production of heat and power.

The method actually employed is to select portions from all parts of a consignment or delivery of coal and to systematically reduce the gross sample, obtained by mixing these portions, to quantities that the chemist requires for making ash determinations or that can be burned conveniently in the calorimeter, an apparatus for determining the heating value. The gross sample should be so large that the chance admixture of pieces of slate, bone coal, pyrite, or other impurities in an otherwise representative sample will affect but slightly the final results. Increasing the size of the gross sample tends toward accuracy, but the possible increase is limited by the

cost of collection and reduction. In reducing the gross sample by successive crushings and halvings or fractional selections, the object is to procure a small laboratory sample that, upon analysis, will give approximately the same results as the gross sample itself, or, in fact, the entire quantity of coal from which the gross sample was obtained.

THE METHOD OF SAMPLING AS A PART OF COAL SPECIFICATIONS.

The method of sampling because of its importance as a definite commercial procedure, is clearly set forth in the specifications in use by the Government, and is made a part of the contract. In order that there may be uniformity and similarity in specifications used by the different branches of the Federal service for the purchase of coal, the Bureau of Mines has prepared specifications for general use by the Government. These specifications in their present form are the result of development following years of experience and satisfactory use by various Government branches. The specifications printed on pages 46 to 58, are typical of the Federal specifications in use for the fiscal year 1915–16. It is recognized that in general specifications, such as presented, certain requirements have to be of wide application, in order to cover a variety of conditions, not only as to character and quality of coal, but as to type of furnace equipment, size of deliveries, and method of delivering.

PRACTICAL CONSIDERATIONS

MOISTURE.

The specifications that were used for the purchase of coal on the heat-unit basis prior to the fiscal year 1912–13 were on the B. t. u. (British thermal unit) "as received" basis; that is, payment for delivered coal was directly affected by the moisture content of the sample received by the laboratory. This method was based on the assumption that the moisture in the samples collected at the time of weighing and delivery could be preserved with slight loss during the storing and subsequent working down of the gross sample to a quantity convenient for transmittal to the laboratory and in its later treatment in the laboratory. From experiments that have been made and from a large mass of data, it is known that the moisture content of coal does not remain constant, and that the moisture content reported by the laboratory may be as much as 5 to 10 per cent lower than that actually contained in excessively wet or high-moisture coal at the time of weighing.

In one investigation, 254 gross samples were reduced, at the delivery point, to samples weighing approximately 5 pounds each and then the 5-pound samples were divided into two equal parts ("duplicates"), which were placed in mailing cans and sent to the Bureau of Mines for analysis. The moisture contents of the "duplicates" were

presumably identical, but analysis showed that the average difference between the moisture contents of the 254 pairs of "duplicates" was 0.256 per cent and the maximum difference was 3.6 per cent. These figures indicate the moisture differences that may exist even after the gross sample has been reduced to approximately 5 pounds, but they do not show the moisture lost by the gross sample while in storage and while being reduced to 5 pounds. As stated above, the total loss of moisture may be as much as 5 to 10 per cent in high-moisture or excessively wet coals..

As a sample loses moisture, its B. t. u. "as received" value correspondingly rises, with the result that the price for delivered coal determined on the "as received" value is, with rare exceptions, higher than that warranted by the quality of the coal at the time of weighing. As a general statement, payment based on the "as received" B. t. u. value will be higher than warranted, unless the sampling and laboratory work can be carried on under conditions that minimize moisture loss, as under freezing temperatures.

Recognizing the uncertainty involved in taking the moisture determination in the laboratory as representative of the moisture content of the delivered coal and the consequent possibility of payment of a higher price than is warranted, the Bureau of Mines recommends that the heating value in coal specifications be on the "dry-coal" basis.

The fact is recognized that the amount of moisture contained in coal produced from day to day from the same mine, or group of mines working the same bed, is largely accidental, and is a matter over which the buyer and seller have only slight control. However, in order to place a negative value on high-moisture coals and to protect the Government against the delivery of coals containing excessive amounts of moisture, the specifications require the bidders to specify the maximum moisture content in coal offered. This value becomes the standard of the contract.

If coal of uniform B. t. u. "dry-coal" value is delivered on a contract, the contractor receives the advantage on any delivery in which the moisture content approaches the maximum specified, because he is paid for the weight of water contained in the coal in excess of a normal amount, whereas if the coal is very dry, containing less than the normal amount of moisture, the purchaser receives the advantage.

For example, coal is delivered under a contract in which the standards are 14,300 B. t. u. per pound "dry coal," and a maximum moisture content of 3.5 per cent. The heating value of a ton (2,240 pounds) of "dry coal" would be 32,032,000 B. t. u. Assume that the average moisture content of deliveries for a year is 2.5 per cent, then for every 2,240 pounds of "dry coal" having a heating value of 32,032,000 B. t. u., the purchaser is required to pay for 56 pounds

of water at the same rate per ton as for "dry coal," but as this percentage of moisture in average deliveries is inherently a constituent of the coal, it is considered as part and parcel of the coal by both the purchaser and the seller. If the coal delivered contains 3.5 per cent moisture, to procure 32,032,000 B. t. u. "dry coal," the purchaser has to pay 1 per cent more for coal because of the excess water above the normal amount, whereas if the coal contains 1.5 per cent moisture, the purchaser pays 1 per cent less. As the variations in moisture content, 1.5 or 3.5 per cent, are largely accidental, the season of the year being partly responsible for them, it is equitable that the purchaser and seller should share the uncertainty. The purchaser justly has a right, however, to demand that the seller shall guarantee a maximum moisture content, as a means of enabling the purchaser to compare one coal with another, as a guaranty that the seller will observe precautions against delivering coal that is unduly wet, and as a basis for adjusting the price of exceptionally wet coal.

The United States Weather Bureau in its annual reports gives the total precipitations per month and the maximum in 24 hours for different sections of the United States. At Washington, D. C., the greatest rainfall recorded for one month is 5.89 inches, and for 24 consecutive hours is 3.67 inches.

As an example of the effect of a heavy rain on a car of coal in transit, a precipitation of 3 inches of water on a loaded 50-ton car, area of top about 360 square feet, would increase the weight of the coal 5.01 per cent, provided none of the water drained out or evaporated. It is obvious that if this coal is weighed and delivered immediately, special samples for moisture determinations should be collected and prepared at once and sent to the laboratory, as a basis for equitable adjustment of payment on account of the excessive amount of water in the coal. As the weight of the coal was increased by the excess water, there should be a corresponding decrease in the price to be paid.

If a railroad car or a wagon so rained on was not unloaded immediately after weighing and the special moisture samples were not properly collected, prepared, and sent hermetically sealed to the laboratory, it is obvious that the purchaser would pay a higher price than warranted, especially if the car or wagon stood for some time before sampling and some of the water drained out. Further, if the coal was not immediately unloaded and sampled or if the car continued in transit after weighing, then the coal at the top would soon dry; and in either case the effect of the 3-inch rainfall, as indicated by the analysis, might be only a fractional percentage of the moisture contained in the coal at the time of weighing.

The determination of the moisture in coal delivered from stock piles is often of great importance, for the proportion of moisture

contained in the small sizes, which are most abundant near the center of a stock pile and which absorb the rains, and melting snows in districts of heavy snows, may be from 10 to 15 per cent higher than when stocked. It is apparent, therefore, that special moisture sample determinations are necessary for equitable adjustment of payment on account of excessive moisture in coal which is stocked in piles exposed to the weather.

The specifications provide for the collection of "special moisture samples" if, in the opinion of the Government officials sampling it, the delivery contains moisture in excess of that guaranteed by the contractor. The "special moisture samples" are prepared in a manner to minimize moisture losses and may be taken and prepared independently of the gross samples collected for the determinations of heating value (B. t. u.), ash, and other specified data. If the analysis of the special sample shows a moisture content in excess of the contractor's guaranty, a proportionate deduction is made from the price to be paid for the coal.

"Special moisture samples" representing coal as delivered should be preserved in such a way as to minimize moisture loss, because if the moisture content of the sample, as shown by analysis, is less than the actual moisture content of the coal at the time it is weighed, either because of the sample being nonrepresentative or because of subsequent moisture loss during the storage or the preparation of the sample, the price to be paid for the coal delivered is correspondingly increased and an injustice is done the purchaser. It is equally important to protect the sample during collection or storage from becoming wet by rain, snow, or water from any other source, in order to insure that the sample represents the delivered coal. Evidently, therefore, particular attention should be given to procuring for the laboratory a sample containing the same percentage of moisture as the delivered coal.

To minimize moisture loss, the sample must be placed in a tight container and stored in a cool place before it is reduced. Moreover the sample should be reduced and transmitted to the laboratory as soon as practicable. It is well to remember that a sample taken from coal that has been exposed to a relatively high temperature, as coal from a boiler or furnace room, or from adjacent bins, has lost moisture and does not represent the coal as delivered. For the same reason the samples should not be stored in a boiler room.

If the contractor does not guarantee a moisure content lower than can be actually maintained on an average, the collection of "special moisture samples" and the making of price corrections on account of excessive moisture will seldom be necessary. Thus, the placing of heating value (B. t. u.) on the "dry coal" basis, with a maximum moisture content, eliminates frequent corrections of price on account of uncertain moisture variations.

ASH AND HEATING VALUE.

The heating value of coal from the same mine or from a group of mines operating the same bed of uniform character is directly influenced by the percentage of ash. By ash is meant earthy matter and impurities that do not burn. As the proportion of ash inherent (sometimes termed "intrinsic ash") in the coal substance as a rule does not vary widely in coal from the same bed, the heating value is largely determined by the amount and character of the free (sometimes termed "extraneous") impurities, and hence the manner in which coal is cleaned and prepared at the mine may greatly affect the heating value of commercial shipments. In collecting samples, therefore, it is of utmost importance that the samples should contain within reasonable limits the same proportion of impurities as the delivered coal from which they were taken.

As the specifications provide for adjustment of price according to the ash content or the heating value, or both, it is evident that samples taken from delivered coal should show, by analysis, practically the same ash content and heating value as the delivered coal. In other words, the sample should contain the same proportion of slate, bony coal, pyrite and other impurities as the quantity delivered, in order that the price adjustment based on the analysis may be fair to both purchaser and seller. Obviously, it is important to guard against any accidental admixture of sand, cement, clinkers, or other foreign matter while the sample is in storage or while it is being prepared for transmittal.

In this connection, attention is called to the fact that the gross sample should contain the same proportion of lump and fine coal as the delivered coal, for it has been determined that fine or slack coal may have an ash content, or a heating value, different from lump coal from the same shipment.

VOLATILE MATTER.

The volatile matter[a] of coal, as shown in analyses, generally contains some inert noncombustible matter, the proportion of which may range from 1 to 15 per cent. The character of the volatile matter in any given coal and the temperatures at which it is given off bear directly on the design and operation of furnaces for burning the coal efficiently and without smoke. The proportion of combustible and noncombustible constituents in the volatile matter and the character of the combustible constituents differ in different coals, and, therefore, the heating value of a coal can not be determined from a proximate analysis. Moreover, different coals with the same proportion of volatile matter may not behave alike in the furnace.

[a] Porter, H. C., and Ovitz, F. K., The volatile matter of coal: Bull. 1, Bureau of Mines, 1910, 56 pp.

In order to determine the comparative value of two coals for the same purpose, it is important to know both their chemical composition and their heating value. Hence the specifications recommended by the Bureau of Mines provide that before final awards of contracts, practical service tests may be made to determine the relative suitability of the coals offered.

In the specifications the contractor is required, in addition to giving the name and the location of the mine or mines producing the coal and the name of the coal bed worked, to specify the volatile matter content and other proximate analysis determinations of the coal he proposes to furnish. The volatile matter content he specifies becomes the standard of his contract, and delivery of coal with a different percentage of volatile matter, indicating the substitution of a coal other than that offered, may result in the coal being rejected and the Government purchasing coal in the open market (the contractor being charged with the difference, if any, in cost) or in the contract being canceled.

The Government does not consider any scheme of applying penalties on account of variations in volatile matter equitable, because the character of the volatile matter and its heating value are not necessarily indicated by the volatile matter determination, and because this determination is made by an empirical method whereby duplicate determinations on the same sample may differ as much as 2 per cent in different laboratories, or, in fact, in the same laboratory. Accordingly, no corrections in price are made for variations in volatile matter.

The bureau has received copies of commercial and municipal specifications drawn up apparently without regard to these facts. One specification, for instance, provides for a correction of 2 per cent in price for each 1 per cent of volatile matter in excess of the standard guaranteed. On a coal sold at $3 per ton a deduction of 12 cents per ton might be made for an apparent excess of 2 per cent in volatile matter, when, in fact, the actual volatile matter of the coal was not above the standard. Specifications of this nature furnish legitimate grounds for opposition from coal companies and do much to discredit the specification method for the purchase of coal.

SULPHUR AND CLINKER.

Sulphur is commonly present in coal in combination with iron or other elements. For a long time it was thought that the sulphur formed clinker, but recent investigations point to the fact that sulphur is not the only cause of clinkering; in fact, there may be no difficulty from clinker in burning coal containing as much as 5 per cent or more sulphur. The relative proportions of iron, sulphur, lime, alumina, silica, etc., in the ash affect its fusibility, whereas the method of

firing and the rate of combustion are important factors in the formation of clinkers. The exact relation of clinkering to the constituents of the ash is not known so well that one can definitely predict from an analysis of the ash whether a coal will or will not clinker. At many power plants the fireman slices the fire too often and works the ash up from the grates into the hot coal bed, where it melts and fuses into heavy, dense masses of clinker. At high rates of combustion the ash in a given coal may clinker (though at lower rates it does not) because of the ash being raised to the fusing temperature. The fact that the percentage of sulphur does not necessarily indicate the behavior of the coal in the furnace is recognized in the specifications recommended by the Bureau of Mines. The contractors, however, are required to specify the sulphur content so that standards for the coals to be delivered may be established.

Many commercial and municipal specifications exact penalties for a slight increase in the sulphur content, although coal of high sulphur content may clinker less and its heating value may be higher. One specification received by the Bureau of Mines exacts a deduction of 5 per cent in price for each 1 per cent of sulphur in excess of the standard. In the case of a coal supplied at $3 a ton, the presence of 1 per cent of sulphur in excess of the standard, as indicated by analysis, would often result in an unwarranted deduction of 15 cents a ton. Under such a contract, the variations which it is recognized exist in sampling and analysis may cause a contractor unjustly to suffer a heavy deduction.

Both the sulphur and the volatile-matter content should be used to classify coals and to identify the coal guaranteed. Variations indicating the substitution of an unsatisfactory coal should be considered cause for rejection of the coal or for cancellation of the contract.

NEED OF EXPERIENCE AND CAUTION IN SAMPLING.

Persons without experience generally select a sample better than the average run of the coal delivered. Occasionally, a lump unusually free from layers of slate and impurities, and representing the best coal in the lot rather than the average, is selected. After being broken it is shipped to the laboratory in a cloth sack, so that it loses moisture during transit. The analysis of such a sample necessarily indicates a value higher than that of the coal delivered. As a quantity of coal may vary greatly in composition, containing not only what may be termed coal proper with certain more or less constant impurities, but also slate, pyrite, and bony coal, a lump may be anything from almost pure coal to material without fuel value. Hence the analysis and test of a single lump may indicate a composition greatly different from that of the coal at hand. It is well to remember that, as the

larger lumps of coal roll down and collect near the bottom of a pile or load, a sample taken entirely from near the floor does not always fairly represent the whole.

In spite of every precaution taken to prevent loss of moisture during the collection, preparation, and analysis of samples, it is certain that loss of moisture may occur; also there may be too little or too much slate, bony coal, or other foreign matter collected in what is otherwise a truly representative gross sample, so that the determination of the heating value or ash content does not strictly agree with the actual value of these factors in the coal delivered. However, an experienced collector, by using good judgment and following the general directions given for collecting and preparing samples, can obtain samples so fairly representative that the results of the analyses are reasonably accurate. The suggestions that follow are presented for the guidance of those who wish to send representative samples to a laboratory for analysis and heating-value tests.

DIRECTIONS FOR SAMPLING.

SIZE OF THE GROSS SAMPLE.

The number of pounds to be taken as a gross sample to represent a given lot of coal varies with the character and condition of the coal, and not with the amount of coal to be sampled. The character and proportion of the bony coal, slate, etc., and the size of the particles of both coal and impurities are the governing factors. It is therefore evident that sampling should not be left to an inexperienced person, but should be done by one who is thoroughly familiar with the significance of these factors and has some knowledge of the coal to be sampled.

There is greater probability of taking too little than of taking too much coal for a gross sample. It is generally true that the larger the gross sample the less is the chance of its being nonrepresentative. Large samples must be taken in sampling coals that carry a varying proportion of large pieces of slate, bony coal, or pyrite, for it is evident that including or excluding large pieces of the impurities must affect the analysis of a small sample considerably; hence, the analysis may not indicate the quality of the coal sampled and, consequently, may be worthless for determining the price to be paid for the coal. If the free impurities are small particles and are well distributed throughout the coal, representative samples may be obtained easily.

Bailey[a] has contributed valuable information to the study of sampling coal. He gives the results of experiments and studies made to determine the size of samples and methods of sampling required

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[a] Bailey, E. G., Accuracy in sampling coal. Paper read before industrial division of American Chemical Society, Baltimore, Dec. 31, 1908. How to sample coal and coke, Fuel Testing Co., Bull. 4, 1910.

for reliable analyses. The "size-weight" ratio or percentage, that is, the ratio of the percentage of the largest pieces of slate to the total weight of the sample, is shown, and appears to be the most important factor for consideration in the sampling of coal. The fundamental principles as stated by Bailey were recognized in the experiments and investigations conducted by the Bureau of Mines. The conclusions reached by the bureau as to the size of samples to be collected, and the sizes to which a sample should be crushed at its various stages of reduction in quantity, substantiate the results of Bailey's work.

As a result of these experiments and tests it has been found that as the size of the sample is decreased the differences between separate samplings become greater and greater. In the case of very small samples[a] the difference may become equivalent to that between pure coal and slate. On the other hand, it has been found that as the weight of the sample is increased, the difference rapidly decreases, until a point is reached where the accuracy obtained by taking larger samples is affected but slightly. This would not ordinarily be warranted, because of the expense which would be involved in making special provisions for handling the very large samples.

The large differences obtained with small samples show very forcibly the necessity for collecting large gross samples in order to insure the results of analyses and reliable heating-value tests, from which the proper price to be paid for delivered coal can be determined and injustice to either seller or buyer prevented.

As a result of the tests it has been established that a gross sample of approximately 1,000 pounds is sufficient to give reliable results for coals comparatively easy to sample; that is, coals relatively free from the "extraneous" impurities. It may be necessary to collect larger gross samples, even 1,500 pounds or more, for coals containing a considerable proportion of impurities in large pieces, or large lumps of coal with streaks of bone, slate, or pyrite, or sulphur balls and lenses.

Whether a delivery consists of 1 ton, 500 tons, or more, the need of the gross sample weighing 1,000 pounds or more is the same. One such sample carefully taken and reduced to a quantity convenient for transmittal to the laboratory can well represent a delivery of several hundred tons, a thousand tons, or more.

For convenience, however, and to avoid long storage of the samples, the Bureau of Mines considers it advisable that one sample of 1,000 pounds, or more, should be collected weekly in the case of Government contracts calling for more or less regular deliveries each week. If, however, the quantity delivered during a week is relatively small, then the sample may represent the coal delivered during

[a] In this bulletin the word slate is used as a commercial, not a geological, term and signifies shale.

a longer period. To facilitate accounting, many branches of the Government service order contractors to deliver in certain quantities, usually 100 to 500 tons. In such cases the samples are collected to represent the order without special regard to the period covered, and one or more gross samples of 1,000 pounds or more each are collected, as may be most practical and expedient in view of the facilities for sampling and the other considerations involved.

In sampling cargo deliveries of 5,000 and more tons, the Bureau of Mines collects from 3,000 to 4,000 pounds of coal as a gross sample. In order that the preparation of the samples may proceed while the cargo is being loaded, after approximately 500 pounds has been collected it is reduced to a quantity convenient for mailing to the laboratory, and each succeeding 500 pounds is likewise reduced. This procedure makes unnecessary the accumulation of a quantity of coal that can not be systematically and conveniently handled in the short time and the small space usually available. Two or more of the samples are combined and reduced to one in the laboratory, and four or five analyses are usually made for a cargo, and a report on the cargo is obtained by averaging the analyses. The samples may, however, be mixed in the laboratory and only one analysis made to represent the cargo. Though the experiments which have been made indicate that a sample of approximately 1,000 pounds will give results fairly representative of the cargo, the objection to the 1,000-pound sample is that it is too small to allow of the frequent collection of shovelfuls or portions of any quantity throughout the loading of a large cargo. As it generally happens that coal from a number of mines is loaded into the same cargo, it is desirable to collect a considerable quantity of coal, so that each mine may be well represented in the gross sample. It is obvious that the more frequently the portions are collected and the greater the quantity sampled, the less the probability that the sample will be nonrepresentative; accordingly, the bureau considers that in sampling 5,000-ton cargoes safety lies rather in the larger gross sample.

WHEN TO COLLECT SAMPLES.

The best opportunities for procuring representative samples are afforded while the coal is being loaded into or unloaded from railroad cars, ships, and barges, or while it is being dumped from wagons. Once the coal is stored in piles or bins, or loaded on cars or vessels, the procuring of representative samples is practically impossible unless the whole quantity of coal is immediately handled again and the conditions for sampling become favorable. Samples collected from the coal exposed in piles, bins, barges, cars, or ships can be considered representative only under the condition that the mass of coal is homogeneous throughout. Such a condition is highly

improbable and uncertain, and the analysis of samples collected from the surface may give results that are very unreliable as indicating the nature of the entire quantity, and that may be worthless as a basis for determining an equitable price to be paid for the coal.

COLLECTION OF GROSS SAMPLES.

When coal is being loaded into or unloaded from wagons, railroad cars, ships, or barges, a shovel or a specially designed tool may be used for taking portions or increments of 10 to 30 pounds to make up the gross sample of coal. As the size of the increments should be governed by the size and weight of the largest pieces of coal and impurities, increments of more than 30 pounds may be required for coals containing large pieces of coal and impurities.

If one chute or conveyor is used for delivering a considerable quantity of coal to or from wagons, cars, or ships, it may prove expeditious and economical to devise a mechanical means for collecting portions from fractional parts of the discharged coal, or continuously deflecting a portion of the coal as it falls down the chute, or diverting from the conveyor definite portions of coal, and thus mechanically and automatically collecting the gross sample.

The mechanical collection of samples is preferred to shovel sampling, as it eliminates the personal equation. The mechanical sampler does not discriminate for or against taking more or less slate or other impurities. A person should collect samples with a shovel in the main without regard to impurities, leaving the amount of the impurities included in a sample largely to chance, as it is impossible to rate correctly the proportion of the impurities concealed in the coal, however competent the sampler may be. A mechanical sampler should preferably take the whole of the stream of coal flowing down the chute a part of the time rather than a part of the stream all the time, because the sizes and character of the pieces of coal and impurities are not apt to be evenly distributed across the stream. Excellent opportunity is afforded for procuring representative samples if the entire consignment of coal is crushed immediately after it is weighed and delivered, for then the samples can be collected from the crushed coal. If the coal is conveyed from the crusher by a conveyor, means can be devised for mechanically and automatically diverting from the conveyor definite portions of coal to make up the gross sample.

The portions should be regularly and systematically collected, so that the entire quantity sampled will be represented proportionately in the gross sample. The interval at which the portions are collected should be regulated so that the gross sample collected will weigh not less than approximately 1,000 pounds. If the coal contains an

unusual proportion of impurities, such as slate, bony coal, and pyrite, and if the pieces of such impurities are very large, it will be necessary to collect gross samples of even 1,500 pounds, or more, but for slack coal and for small sizes of anthracite, if the impurities are not in abnormal proportion or in pieces larger than about three-quarters of an inch, and are evenly distributed throughout the coal, a gross sample of approximately 600 pounds may prove sufficient. The gross sample should contain the same proportion of lump coal, fine coal, and impurities as the coal delivered. As soon as the portions are collected they should be deposited in a receptacle having a tight-fitting lid provided with a lock.

WAGONLOAD SAMPLING.

A gross sample taken by hand from coal delivered by wagon at a Government building should consist of shovelfuls of coal taken from the first, second, or third wagonload as it is being discharged, the number of shovelfuls taken and the loads sampled being dependent on the number of loads which the gross sample is to represent. If the coal is discharged immediately into a crusher, it is preferable to collect shovelfuls of the crushed coal.

If it is desired to sample coal delivered in small lots by wagons to a large number of buildings from one source of supply where the coal is all weighed, and if the collection of samples at each building will involve considerable expense, samples may be conveniently collected at minimum expense at the source of supply when the coal is loaded into the wagons. In such case the samples are collected without regard to delivery points, the object being to sample the coal loaded into the wagons. At the end of the month or upon the completion of an order the corrected price per ton, if there be any corrections on account of coal varying from the standards guaranteed by the contractor, applies to each individual delivery point. Shovelfuls of coal should be taken from each wagonload, or every second or third, etc., wagonload, the number of shovelfuls taken and the number of wagonloads sampled being dependent upon the number of loads which the gross sample is to represent.

It is important to obtain representative portions of coal from every part of the delivery, so that the sample will show the quality of the delivery or order as a whole. The gross sample should contain about the same proportion of lump coal, fine coal, and foreign matter as the coal delivered.

CARLOAD SAMPLING.

Samples taken from railroad cars should not be limited to a few shovelfuls of coal procured from the top of a car, for the size of the coal and the proportion of foreign matter may vary from the top to

the bottom of the car. The only way to obtain a representative sample is to take a number of shovelfuls or portions of coal from different points in a car, from top to bottom and from end to end, while the coal is being loaded or unloaded.

When a shipment of coal is sampled at the mine, shovelfuls or portions of coal should be taken systematically as the coal is loaded into the railroad car, and with such regularity that the sample will represent the entire carload. The frequency of collecting the portions will depend on the number of cars of coal to be represented by one gross sample. If only one carload is to be sampled, a gross sample of 1,000 pounds, or more, should be collected. If two or more cars of coal are to be represented by the sample, proportionate amounts to make up the gross sample should be taken from the coal as it is loaded into each car. The samples should be taken after the coal has been prepared for market; that is, if the coal is passed over picking tables or pickers are employed on the car to remove the impurities from the coal, the samples should be taken only after the coal has had its final preparation.

When sampling coal delivered from open cars and unloaded by hand shovelfuls should be taken at regular intervals as the coal is unloaded into wagons or bins.

When coal is being sampled from dump cars, ladlefuls (see p. 19) or shovelfuls should be taken from the stream of coal being discharged to the bins or ship. If the discharged coal is immediately crushed the gross sample should preferably be collected after the coal leaves the crusher.

If a number of carloads are delivered on an order or during a short period the preparation of a gross sample of 1,000 pounds or more for each car would involve considerable time, labor, and expense at the delivery point, as well as in the laboratory; in fact, a gross sample for each car would not be required, for if a gross sample is carefully taken and prepared it can well represent a number of cars. If a gross sample is collected to represent two or more cars representative portions of the coal should be taken in equal quantities from each car.

The method followed by the Bureau of Mines in sampling coal discharged from railroad cars directly into ships is given under "Cargo sampling."

CARGO SAMPLING.

In sampling cargoes, as in sampling carloads, portions of coal should be taken in equal quantities and at frequent and regular intervals so as to represent proportionate parts of the consignment as a whole, either while the coal is being loaded or unloaded. There is no assurance that a sample or a series of samples taken from the top of the cargo represents the cargo as a whole; in fact, it is very doubtful if such samples are ever representative

The Bureau of Mines has charge of the sampling of cargo shipments of coal to the Isthmus of Panama for the Panama Rail Road Co. The coal, which is loaded from piers at Hampton Roads, Norfolk, and Newport News, Va., is dumped directly from railroad cars into ships carrying from 4,000 to 12,000 tons of coal. The method followed is to collect portions of coal from every railroad car dumped. From 30 to 60 pounds are taken from each car sampled, the quantity taken depending on. the size of the cargo. From 3,000 to 4,000 pounds are usually collected as a gross sample to represent a cargo (see p. 15 under "Size of the gross sample"). The gross samples are reduced in successive stages as collected, rather than accumulated and later reduced to quantities convenient for transmittal to the laboratory.

The portions making up the gross samples are taken from the coal as it is discharged from the bottom-dump cars by the use of a shovel or a specially constructed ladle. The ladle has a handle about 5 feet long and a bowl 1 foot in diameter at the top, 9 inches at the bottom, with depth of $9\frac{1}{2}$ inches, and holds from 25 to 30 pounds of coal. To collect samples with the ladle, it is rested on the rails of the track or on the chains that support the gates of the car. Two ladlefuls are usually taken from a car, one from one side and the other from the other side at the opposite end, thereby obtaining portions from different parts of the car. Care is observed to not collect portions of the first or last coal spilling from the car, for the moisture content or proportions of foreign matter in such coal may render the sample unrepresentative. If circumstances permit, the ladle is shifted and filled from different sections of the stream of falling coal. It sometimes happens that the coal is discharged very rapidly, in which case the collector must be alert to collect portions at the most desirable periods and must take care that the coal does not wrench the ladle out of his hands or jerk him down and do him bodily injury.

The method of sampling cargo shipments has been established as the result of numerous experiments, and it has been determined that the analytical reports obtained are representative within limits reasonably to be expected for work of this nature.

The bureau is making a study of the conditions on the piers, with a view of devising means whereby the samples can be automatically and mechanically collected, prepared, and reduced to quantities convenient for transmittal to the laboratory. At one of the three railroad terminals loading at Hampton Roads, Va., the bureau has installed a crusher for crushing the gross samples to $\frac{3}{16}$-inch mesh and finer, and parting devices for reducing the samples in quantity, thereby eliminating the hand preparation of samples. It is proposed to install crushers and equipment at the other two points.

Because of the suddenness with which the coal may break through and drop out of the railroad car after the gates are open and because of the momentum of the rapidly falling coal, it may be impossible to collect a satisfactory sample by attempting to catch coal in a shovel or ladle. In such event, it may be necessary to collect shovelfuls of the coal that has overflowed on the pier. If beams 10 to 12 inches wide span the pockets immediately underneath the car, a fairly satisfactory sample can often be collected in shovelfuls from the coal lodging on the beams.

Though the collector may use the shovel or ladle to the best of his ability, these tools may collect portions of coal that do not contain lump coal in the same proportion that exists in the car. Especially may this occur if the coal contains a large proportion of lumps of considerable size. In that event, the collector should collect portions of lumps from time to time and add them to the sample. Necessarily the collector must be relied upon to collect a sample under these conditions that will fairly represent the proportions of lump and slack coal contained in the coal sampled, and it follows that the collector must have experience in sampling and be able to judge the coal and the sample.

In sampling large quantities of coal in a short period, the collector frequently works under disadvantages and has not the opportunity to select more leisurely and methodically portions of coal to make up a gross sample, as he can in sampling wagonload deliveries or in single carloads or barges unloaded by shovel, clam shells, or grab buckets, and this fact should be considered in comparing the results of sampling cargo with wagon or railroad-car deliveries.

In collecting samples from coal as it is unloaded from a ship, the same general instructions apply; the cargo being systematically sampled during the entire period of unloading, so that samples will be collected which represent the quantity as a whole. If unloaded by grab buckets or into barrows, shovelfuls should be collected at regular intervals from the buckets or barrows. If the coal is crushed immediately after it is unloaded, it is preferable to collect samples from the crushed coal.

SAMPLE RECEPTACLE.

As the wagons or railroad cars may arrive irregularly at the building or plant and the coal be intermittently unloaded, a metal receptacle or wooden box of a size to hold a gross sample of at least 1,000 pounds, with a tight-fitting lid which can be locked, is required for holding the portions of coal taken from each wagon or car until the gross sample is completed. In sampling cargo deliveries, buckets holding 60 to 70 pounds may prove more satisfactory to use for receiving the portions making up a gross sample, as the samples are

usually worked down as the loading progresses and the buckets are convenient for carrying the coal to the space available for preparing the gross samples. If the gross samples are stored, a box should be provided or else a sufficient number of buckets with tight-fitting lids and locks should be available in order to preserve the integrity of the sample.

The buckets, boxes, or receptacles should be inspected each time before using and thoroughly cleaned to remove the coal dust remaining from previous samples and any foreign matter that may by chance be in them.

COLLECTION OF SPECIAL MOISTURE SAMPLES.

During the collection of gross samples and their reduction to quantities that are convenient for transmittal to the laboratory and that correctly represent the ash, sulphur, and heating value of the coal sampled, it is ordinarily impossible to retain in the sample all the moisture that was in the delivered coal. Obviously, if it is desired to determine the amount of moisture in delivered coal, special moisture samples are usually necessary. Owing to the fact that a sample unavoidably loses moisture during every stage of handling and preparation, the special moisture samples must be, in a sense, grab samples and must be collected, prepared, and placed in a sealed container with as little delay as possible.

If a gross sample is collected during a period of a few hours or a very few days and the sample is collected and stored under conditions that will preserve its moisture content, a special moisture sample may be collected from the gross sample after it has been rapidly crushed, so that it will all pass through a 1-inch screen (the fineness to which the gross sample is reduced by the first crushing, see table on p. 25). It should be collected in a place comparatively cool and protected from rain, snow, wind, and the sun's rays. A small scoop may be used for collecting the sample. The scoop should have a capacity of about one pound of coal—a scoop with bottom about $2\frac{1}{2}$ inches wide and $8\frac{1}{2}$ inches long and vertical sides about 2 inches high is about the right size. As the crushed coal is shoveled into a conical pile (p. 26), scoopfuls should be regularly and systematically collected so that approximately one scoopful will be collected to every two shovelfuls (about 30 pounds) deposited on the cone, thereby collecting a special moisture sample weighing from 30 to 50 pounds. As the scoopfuls are collected they should be placed in a receptacle which can be tightly closed. After the gross sample has been formed into a conical pile (p. 26) and the special moisture sample weighing 30 to 50 pounds has been accumulated, the special moisture sample should be immediately and rapidly crushed so that no pieces

of coal or impurities are larger than one-half inch; and it should be rapidly coned, flattened, and quartered, and a mailing can (p. 32) filled by taking portions from each quarter by use of the scoop (each portion only partly filling the scoop). The mailing can should be properly sealed at once (p. 36) and forwarded to the laboratory.

If the gross sample in the above case is crushed mechanically and reduced to the quantity desired for transmittal to the laboratory by use of sampling machines in such a manner and in machines so designed that moisture losses are minimized, then the collection of a special moisture sample may prove unnecessary, as the moisture determination made on the regular sample will represent, within reasonable limits, the moisture content in the coal delivered.

If a gross sample is collected during a period of several days, and if it is manifest that the sample will lose moisture during its storage and preparation, the special moisture sample should be accumulated by placing in a receptacle small portions of the freshly taken increments making up the gross sample. Under these conditions it is desirable that a receptacle which can be hermetically sealed and has a capacity of about 100 pounds be provided in which to preserve the portions making up the special moisture sample as they are taken each day. After the gross sample is accumulated a quantity convenient for transmittal to the laboratory should be selected from the special moisture sample (in accordance with the method given above) and forwarded in the mailing can, properly sealed for special moisture determination.

If two or more railroad cars are to be represented by one gross sample, and if the cars contain different amounts of moisture seemingly in excess of the maximum moisture content guaranteed, moisture samples should be taken separately from each car. If a single gross sample is to represent several days' delivery, and if because of heavy intermittent rains there is a considerable difference in moisture content between each day's delivery, and each contains moisture in excess of the maximum content guaranteed, then a special moisture sample should be taken representing each day's delivery. Payment for the entire quantity on account of ash and B. t. u., "dry coal," is determined from the analysis of the gross sample, but corrections on account of excessive moisture should apply to the particular car or cars, or day's delivery. The purchaser would be at a disadvantage on account of heavy rain if corrections for moisture did not apply to each day's delivery or fraction of the delivery, because if the special moisture samples were mixed, and one special moisture determination only made, the effect of the heavy rains would largely be averaged out in the mixture, and, in addition, in storing, mixing, and reducing the samples there would be more or less moisture lost.

PREPARATION OF THE GROSS SAMPLE.

Though a gross sample may be collected ever so carefully and may represent the coal sampled, unless it is prepared in accordance with well recognized principles, the results of analysis and test may be worthless for determining equitable settlement for the coal.

The portions taken in making up the gross sample should be immediately placed in a box or a receptacle having a tight-fitting cover and a lock, for storage in order to preserve its integrity until it is reduced to a quantity convenient for transmitting to the laboratory.

If it is desired to determine the moisture content of a gross sample that has been collected in a comparatively short time under precautions to minimize moisture loss, the sample should be placed in a comparatively cool place and the crushing, mixing, and reduction for shipment to the laboratory should be done as rapidly as possible; this is imperative if the analysis of the sample is to represent the approximate condition of the coal with respect to its moisture content at the time it was weighed. Obviously, a sample on which a moisture determination is desired should be protected from rain and snow and strong air currents or winds and the sun's rays during its storage and preparation.

The proper preparation of a gross sample for shipment to the laboratory involves three operations: (1) Crushing, (2) mixing, and (3) reduction in quantity. The operations proceed in stages until the final sample is obtained.

The crushing may be done by a mechanical crusher or by hand with an iron tamping bar or sledge on a smooth, clean, sheet-iron plate, of suitable dimensions, or on a solid floor—in the absence of a sheet-iron plate or smooth, tight floor, the crushing may be done on a heavy canvas—to prevent the accidental admixture of any foreign matter. The mixing and reduction may be done by hand with a shovel, or mechanically by means of riffles or sampling machines.

It is obvious that if the gross sample is reduced in quantity without crushing, the effect of the selection or rejection of one or more of the large pieces of slate or other impurities in the portion of the sample retained multiplies rapidly as the sample becomes smaller. To illustrate: A sample of 1,000 pounds contains a piece of slate weighing 1 pound, which is one-tenth per cent of the weight of the gross sample. If the sample is halved in quantity without crushing, the half of the sample retained for further reduction will contain two-tenths per cent ash more or less than the rejected half, according to whether the piece of slate went into the retained half or into the rejected half. In halving the 500-pound sample, the 1-pound piece of slate would have an effect of four-tenths per cent on the ash content of either the retained or rejected half. If, in continuing the reduction of the sample

by halving each time, the 1-pound piece of slate by chance should fall into the retained half on each successive halving, it would have an effect of 12.8 per cent on a $7\frac{13}{16}$-pound sample—that is, in halving the $15\frac{5}{8}$-pound sample the 1-pound piece of slate would cause the ash content of one-half of the sample to be 12.8 per cent higher than the other; in other words, if the average ash of the coal is 10 per cent, one of the $7\frac{13}{16}$-pound samples would show an ash content of 22.8 per cent. This fundamental principle that the weight of the largest piece of impurities should be relatively very small in ratio to the weight of the sample at each halving is recognized in the instructions for sampling issued by the Bureau of Mines, which specify that the sample should be successively crushed, mixed, and reduced.

In the sampling of ores it is recognized that the particles of ore must be crushed to varying degrees of fineness in order to obtain results within an allowable limit of error, and to accomplish this, elaborate and costly plants are constructed and maintained. Brunton [a] states that experiments and calculations and a general consideration of the subject indicate that the size to which ore must be crushed for sampling in order to reduce error within an allowable limit will depend on:

1. The weight or bulk which the sample is to have. Evidently the smaller the sample the finer the material must be crushed.

2. The relative proportion between the value of the richest mineral and the average value of the ore. If the average grade of the ore is high in comparison with the grade of the richest mineral, a particle of richest mineral of a given size and value will have less percentage effect on the sample than the same particle would have on the same amount of lower-grade ore; therefore, other conditions being the same, with high-grade ores we may crush more coarsely than with low-grade ores and still keep within the same percentage of error; while if the richest mineral is of comparatively high grade a particle of it of given size will have a greater effect on the sample than if it is of low grade, and this will necessitate finer crushing.

3. The specific gravity of the richest mineral. The higher the specific gravity of the richest mineral the greater the value contained in a particle of given size and grade, and hence the greater the influence of such particle on the sample; from which follows the necessity of keeping down the size of the largest particles by finer crushing than is required when the richest mineral is of lower specific gravity.

4. The number of particles of richest mineral which are likely to be in excess or deficit in the sample is evidently an important factor, a liability to a large number necessitating especially fine crushing. But such liability can result only from imperfect mixing, and for material mixed with average thoroughness this number must be small.

And in conclusion this paper further states that:

The results of the investigations recorded in this paper show how absolutely necessary it is that ore samples should be recrushed after each successive "cutting down," so that as the sample diminishes in weight there may be a nearly constant ratio between the weight of the sample and that of the largest particle of ore contained therein.

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[a] Brunton, D. W., The theory and practice of ore-sampling, Trans. Am. Inst. Min. Eng., 1895, vol. 25, p. 827.

In applying these principles to coal, slate and other impurities are to be considered as taking the place of the "richest mineral," but, as coal is a low-priced commodity, the cost of collecting and preparing samples must necessarily be correspondingly small, making the installation and operation of elaborate sampling plants prohibitive.

Though the fineness to which the Bureau of Mines specifies that samples be crushed may not be strictly in accordance with the fineness that would be necessary for theoretically accurate reduction of the samples, and as coal of a definite physical character and composition would require special treatment, the fineness specified in the table below, it is believed, will give results that are fairly representative.

When prepared by hand the pieces of coal and impurities should be crushed to sizes not greater in any dimension than the sizes indicated in the following table before each reduction of the sample into two approximately equal parts:

Size of coal and quantity required for each reduction.

Largest size of coal and impurities allowable in sample before division.	*Weight of sample to be divided, pounds.*
One inch	1,000 or more.
Three-quarters of an inch	500
One-half inch	250
Three-eighths of an inch	125
One-quarter of an inch	60
Three-sixteenths of an inch, or 4-mesh screen	30

Diagram showing the treatment of a 1,000-pound sample.

1,000-pound gross sample, crush to 1-inch mesh; mix by coning and long-pile method; halve by alternate shovel method.

Rejected portions.

500 ↓ — 500 pounds, crush to $\frac{3}{4}$-inch mesh; mix by coning and long-pile method; halve by alternate shovel method.

250 ↓ — 250 pounds, crush to $\frac{1}{2}$-inch mesh; mix by coning method; halve by quartering method.

125 ↓ — 125 pounds, crush to $\frac{3}{8}$-inch mesh; mix by rolling on blanket; halve by quartering method.

$62\frac{1}{2}$ ↓ — $62\frac{1}{2}$ pounds, crush to $\frac{1}{4}$-inch mesh; mix and halve by blanket and quartering method.

$31\frac{1}{4}$ ↓ — $31\frac{1}{4}$ pounds, crush to $\frac{3}{16}$-inch or 4-mesh; mix and halve by blanket and quartering method.

$15\frac{5}{8}$ ↓ — $15\frac{5}{8}$ pounds; mix and halve by blanket and quartering method.

→ $7\frac{13}{16}$ pounds.
Fill 5-pound container and mail to laboratory.

$7\frac{13}{16}$ pounds.
Fill 5-pound container
for reserve sample.

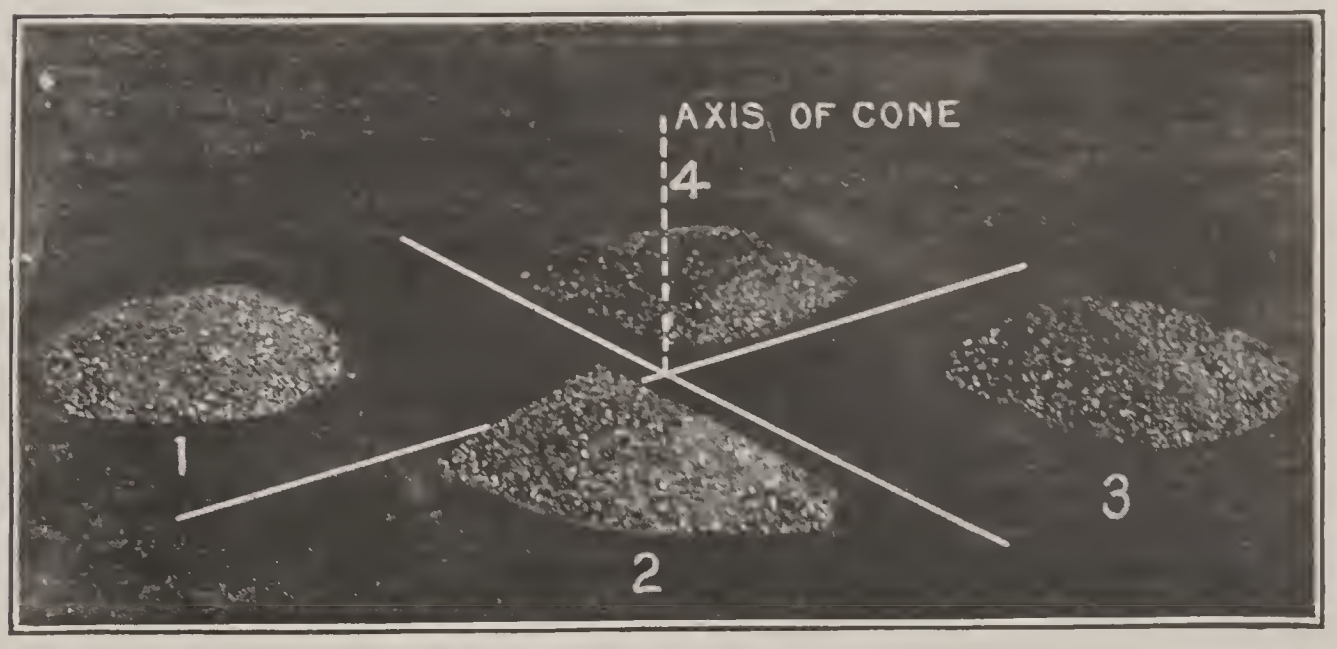
Care should be exercised to crush finely pieces of foreign matter before each reduction so that the crushed impurities can be distributed through the sample, and when crushing to keep pieces of slate and other impurities from flying out of the sample. In crushing the coal on wood, brick, cement, or on floors of such materials, splinters or small fragments may be broken from the floor and be mixed with the sample. Such floors, if used, should be thoroughly clean and free from cracks. If a sheet-iron plate is used, it should be free from rust.

After each crushing the sample should be thoroughly mixed before reduction in quantity. The method which gives generally satisfactory results is as follows:

The crushed coal is formed into a conical pile by depositing each shovelful of coal on top of the preceding one (see Pl. I, *A*, which shows approximately 1,100 pounds of coal crushed to 1-inch mesh and finer, properly coned.) As the shovelfuls are deposited the fine material forms the apex of the cone, while the coarse particles roll down toward the base. By walking around the cone and systematically depositing shovelfuls on the apex of the cone from every side, care being taken to maintain the original form, the sampler will properly distribute the fine and coarse coal. A new, long pile is then formed by taking a shovelful at a time (as the sampler fills the shovel he should walk around the cone, thus systematically removing the coal from the base of the cone) and spreading it out in a straight line or ribbon the width of the shovel; the length is 5 to 10 feet for a shovel holding about 15 pounds. Each new shovelful is spread over the top of the preceding one, beginning at opposite ends, and so on until all the coal has been formed into one long pile. (Pl. I, *B*, shows the coal of the cone formed into a long pile.) The sample is then halved in quantity by shoveling the long pile to one side, alternate shovelfuls being discarded while the retained shovelfuls are formed into a new cone. In shoveling the coal from the long pile the sampler takes the shovelfuls of coal systematically around the pile, advancing at each shovelful a distance about equal to the width of the shovel, thereby preserving the symmetry of the form of the pile. If the pile should be reduced by shoveling all of the coal from either end, and if the alternate shovelfuls discarded contained coal mainly from the sides of the pile, the rejected half of the sample would contain a preponderance of coarse coal, while the retained half would contain relatively too much fine coal. This is because the coarse coal rolls down the sides of a pile or cone while the fine coal builds up, so that the relative proportions of coarse and fine coal in outer and inner portions of the pile are quite different. The alternate shovelfuls of coal which are retained are formed into a new cone.

A. CRUSHED GROSS SAMPLE IN CONICAL PILE.

B. CRUSHED GROSS SAMPLE REMIXED IN LONG PILE.



C. REDUCED SAMPLE QUARTERED.

In coning, care should be observed to deposit each shovelful so that the center of the cone as started will not be drawn to one side, for in quartering a cone the center of which has been drawn, two opposite quarters will contain an excess ratio of fine material, while the other two quarters will contain a deficiency. This will be apparent when it is considered that when a cone is formed, the fines build up the apex while the coarse particles roll down the sides. In ore sampling this may be of especial importance, as the fines are generally the richest ore, and as a result the metallic content of the final sample will be more or less than the average of the original pile, depending upon which two quarters are retained. D. W. Brunton, in a paper entitled "Modern Practice of Ore-Sampling," [a] shows by illustrations and an example the effect of "drawing the center." He takes as an example the reduction of a 2,000-pound lot of ore to $62\frac{1}{2}$ pounds (requiring quartering five times), and supposing that at each stage the sample taken represented 98 per cent of the actual value of the cone, he shows that the final sample would only give 90.3 per cent of the true value of the cone.

After the gross sample has been reduced by the coning, long-pile, and alternate shovel methods to approximately 250 pounds, the sample is further reduced in quantity by the quartering method. Before each quartering, the sample is thoroughly mixed and made into a conical pile, as follows:

Quantities of 125 to 250 pounds are shoveled into a new conical pile by depositing each shovelful of coal on top of the preceding one; quantities less than 125 pounds are placed on a suitable cloth, measuring about 6 by 8 feet, and mixed by raising first one end of the cloth and then the other, rolling the coal back and forth. After the coal is thoroughly mixed it is formed into a conical pile by gathering together the four corners of the cloth. The conical pile is quartered as follows:

The cone is flattened, its apex being vertically pressed down with a shovel or a board, so that each quarter contains the material originally in it. The flattened mass, which should be of uniform thickness and diameter, is then marked off into quarters with a board held edgewise, or a piece of sheet iron, along two lines that intersect at right angles directly under the apex of the original cone. The diagonally opposite quarters are shoveled away and discarded, and the spaces which they occupied brushed clean (Pl. I, *C*, shows the four quarters and the intersecting lines; quarters 1 and 3 will be rejected). The coal remaining is successively mixed, coned, and quartered on the canvas until two opposite quarters are about equal to the quantity (approximately 5 pounds) required to fill the sample container for shipment

[a] Am. Inst. Min. Eng., vol. 40, p. 571, presented at the Spokane meeting, September, 1909.

to the laboratory. If after two opposite quarters are placed in the sampling container, it is found that the container is not compactly filled, the other two quarters should be mixed, coned, flattened, and quartered, and the remaining space in the container then filled by taking equal segments from opposite quarters, using the sampling scoop (p. 21). The two rejected quarters are not thrown into the discard, but are placed in a sampling container, hermetically sealed, and held in reserve at the delivery point until report of analysis of the regular sample is received and settlement made for the coal.

The operations and methods followed in preparing and reducing the gross sample to a quantity convenient for transmittal to the laboratory are diagrammatically shown on page 25. The treatment of the 5-pound sample when it is received by the Bureau of Mines is diagrammatically shown on pages 34 and 35.

Accuracy in reducing the gross samples requires that the coal be crushed as directed, thoroughly and systematically mixed, formed in piles, and accurately divided, either by the alternate-shovel method or by quartering, so that the rejected portions and the retained portions will be uniform in character and weight. Thorough cleanliness must be maintained during the entire operation.

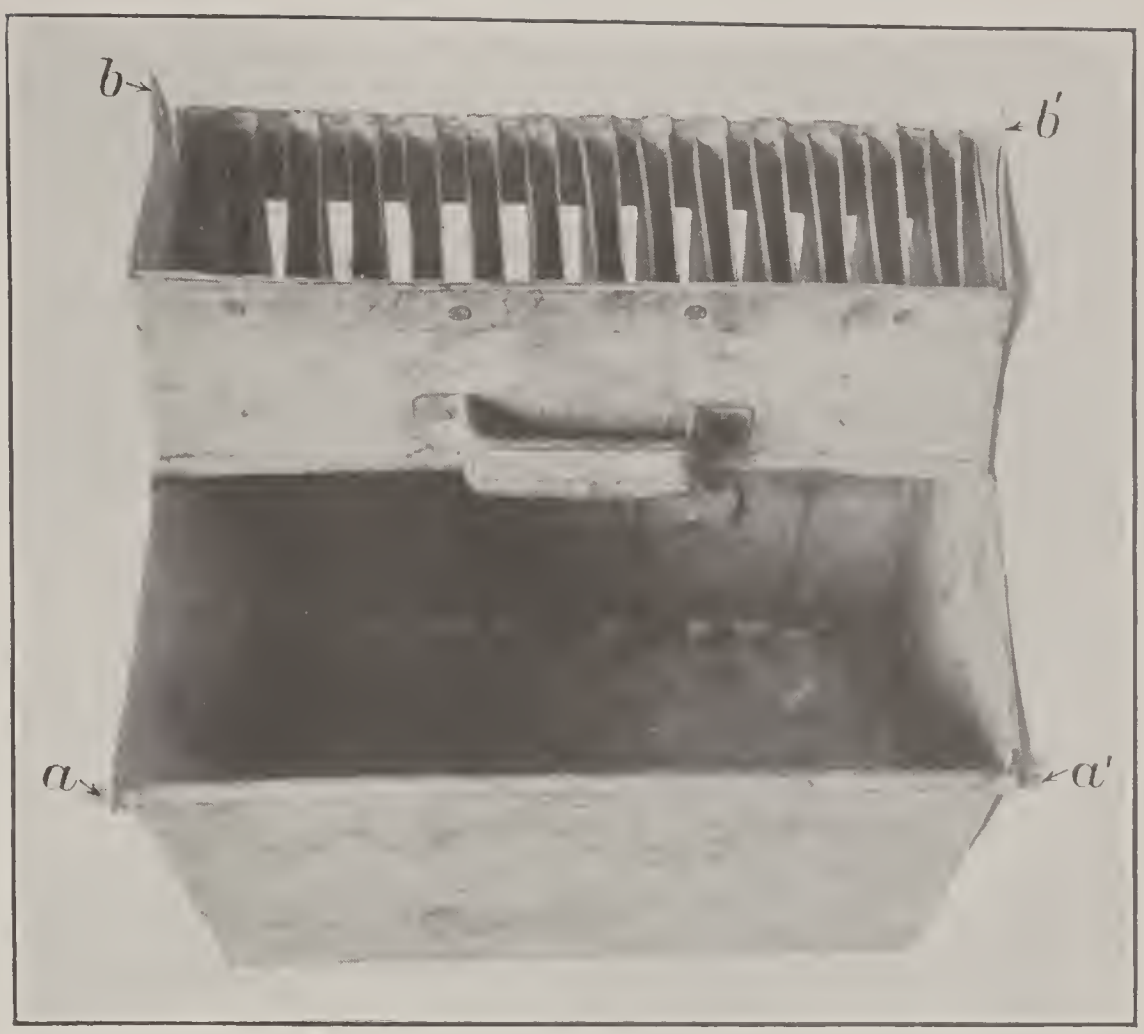
The method of coning and quartering coal and the principles which must be recognized are in essential features as given by Richards [a] for reducing ore samples.

Whenever the different increments of samples are collected throughout some considerable period of time, each increment may be crushed as soon as taken, and the pieces of coal and impurities may be broken sufficiently small to permit two or more reductions of the accumulated samples before further crushing is necessary.

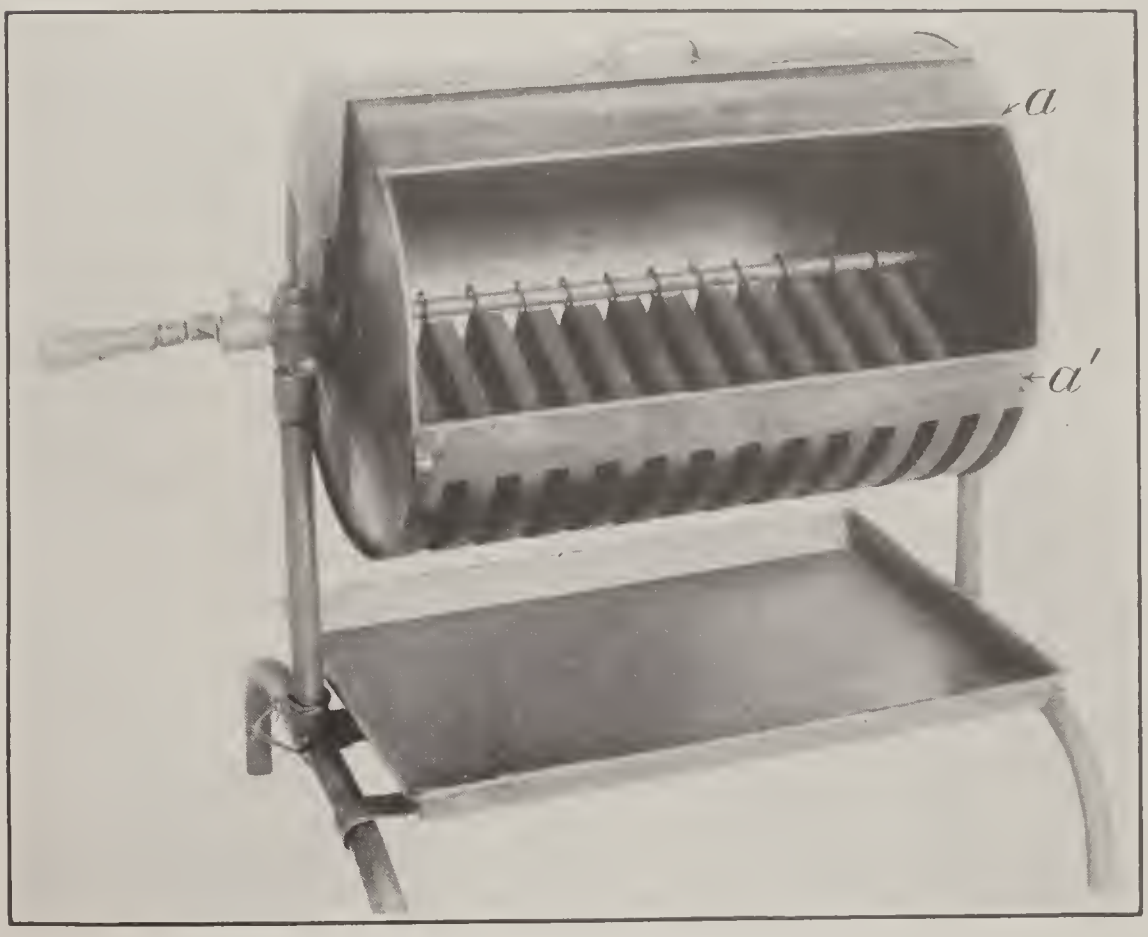
If deliveries extend over a considerable period, what would otherwise be a gross sample may be worked down, as it accumulates, in successive stages to quantities of a size suitable for transmittal to the laboratory, and these fractional samples may be analyzed and the several analyses averaged, or they may later be mixed (at the delivery point or in the laboratory and reduced to one sample) and one analysis made. In averaging analyses or in mixing the several samples, weights should be used in proportion to the tonnages that the fractional samples represent.

If the contract amounts to a considerable quantity, necessitating several samples in relatively short periods, the installation of a crusher has been found in some cases expedient and economical for reducing the gross samples to three-sixteenths inch mesh, or finer, and in such case, instead of the mixing and reducing being done by hand, the reducing buckets or mixing and reducing machine shown in Plate II are used. Even though the contracts are relatively small and

[a] Richards, R. H., Ore dressing, vol. 2, p. 844, and vol. 3, pp. 1574–1578.



A. SAMPLING BUCKET.



B. MIXING AND REDUCING MACHINE.

the samples are crushed by hand, the use of the reducing bucket or machine is recommended. These devices are generally used after the gross sample has been mixed and has been reduced by the "alternate shovel" and quartering method to about 60 pounds.

After the gross sample has been reduced to less than 250 pounds, a shovel takes too large a proportion of the coal, making further reduction by alternate shovelfuls unreliable. The quartering method is used after the sample has been reduced by alternate shovels to approximately 250 pounds, as the capacity of an ordinary shovel is out of proportion to the size of the sample. It may prove desirable in sampling coal containing considerable quantities of free impurities of uneven size to use small shovels of 10 pounds and less capacity in reducing the gross sample by alternate shovels, for as the size of the shovel is diminished the number of fractional parts into which the sample is divided is increased. As the sample becomes smaller, greater precision in quartering is required, and, consequently, refinements in the manner of mixing and reducing should be introduced. The use of buckets or the machine makes thorough mixing possible and the riffles insure accurate division.

A mechanical crusher and mechanical means for preparing the samples for transmittal to the laboratory may be installed and the collection and preparation of the sample can then be made a continuous and purely mechanical process. When mechanical crushers are used the sample should be inspected before or while being fed to the crusher to make certain that the sample does not by chance contain a piece of iron, such as a tie spike or some other highly abrasive substance, accidentally loaded with the coal in the mine and undetected in collecting the sample, otherwise the abrasion of the iron may introduce errors which would alter appreciably the final results.

As it is so important that samples shall be carefully and systematically prepared by a prearranged plan, in order that their analyses will serve as an equitable basis for the determination of the price to be paid for coal purchased under the specification method, the specifications used by the Government give the method of sampling, as described above, in considerable detail. To assure its being clearly understood the method of sampling specified in a contract may be illustrated. The instructions which accompany the specifications given on pages 46 to 58 have been illustrated (Pl. V) to show the hand preparation of samples.

SAMPLING BUCKETS.

When the sampling buckets are used, two similar ones are required. About half of the top of each bucket is covered with a riffle. The coal is placed in one of the buckets, and the projections *aa'* (Pl. II, *A*) of the stiffening rod of this bucket are placed in the notches *bb'*

of the second bucket. The coal that is poured from the first bucket flows to the riffle of the second bucket; every alternate section cut out by the riffle is discarded and the other sections are caught in the second bucket, thus halving the sample. The sample is poured from one bucket to the other until it is reduced to about 5 pounds, but the discarded 5-pound half is placed in a container and kept as the reserve sample.[a]

THE MIXING AND REDUCING MACHINE.

If more thorough mixing than can be done with the buckets is desired, the mixing and reducing machine is used. Plate II, *B*, shows the apron of the cylinder of this machine open for receiving a sample. After the sample is poured in, the apron's position is shifted, *a* being moved to *a'*. The cylinder is then closed and revolved counterclockwise. The closed sides of the riffles plow through and thoroughly mix the coal, and no coal can be discharged through the riffle while the cylinder is revolved in this direction if the level of the coal is below the axis of the cylinder. After the sample has been mixed, the cylinder is rotated one turn clockwise; the coal in the cylinder is then cut by the planes of the riffle and half of it is discharged into the receiving tray. The coal remaining is again mixed by revolving the cylinder counterclockwise. By alternately changing the direction of rotation, the coal is alternately mixed and halved until about 10 pounds remain in the cylinder. The tray is then emptied of the discarded coal and the 10-pound sample mixed and halved, and the 5-pound sample caught in the tray is put in a container and becomes the official sample while the 5-pound sample remaining in the cylinder is put in a container and held as the reserve sample. The interior of the machine is easy of access and should be brushed clean after each sample.

Generally speaking, the use of mechanical means for sampling coal and preparing samples gives more reliable and satisfactory results than hand labor, as the personal equation is partly eliminated.

COLLECTION OF SAMPLES IN THE DISTRICT OF COLUMBIA.

Gross samples are collected from deliveries under Government contracts in the District of Columbia in accordance with the method given in the specifications and as set forth in this paper. Instead of the gross sample being reduced to 5 pounds, as is necessary in the case of deliveries elsewhere, the sample, after it is reduced to 125 to 250 pounds, is placed in galvanized-iron buckets, each large enough to hold about 70 pounds of coal and having a close-fitting lid that can be locked. The locked buckets of coal are immediately delivered to the crushing room in the Bureau of Mines building, where the preparation of the sample for the laboratory is continued.

[a] Buckets of this type are a rapid and reliable means of reducing samples. The riffles of the buckets first developed were of galvanized iron. Difficulty in having these riffles skillfully made and the frequent repairs from rough usage indicate that buckets made of steel plates and channel irons would prove more serviceable.

THE SAMPLING ROOM.

For preparing the samples collected in Washington, after they have been reduced at the delivery point to 125 to 250 pounds, specially designed machinery is installed in the sampling room of the Bureau of Mines plant. The samples are put through a motor-driven hammer crusher which crushes the coal to pass a $\frac{3}{16}$-inch mesh screen.

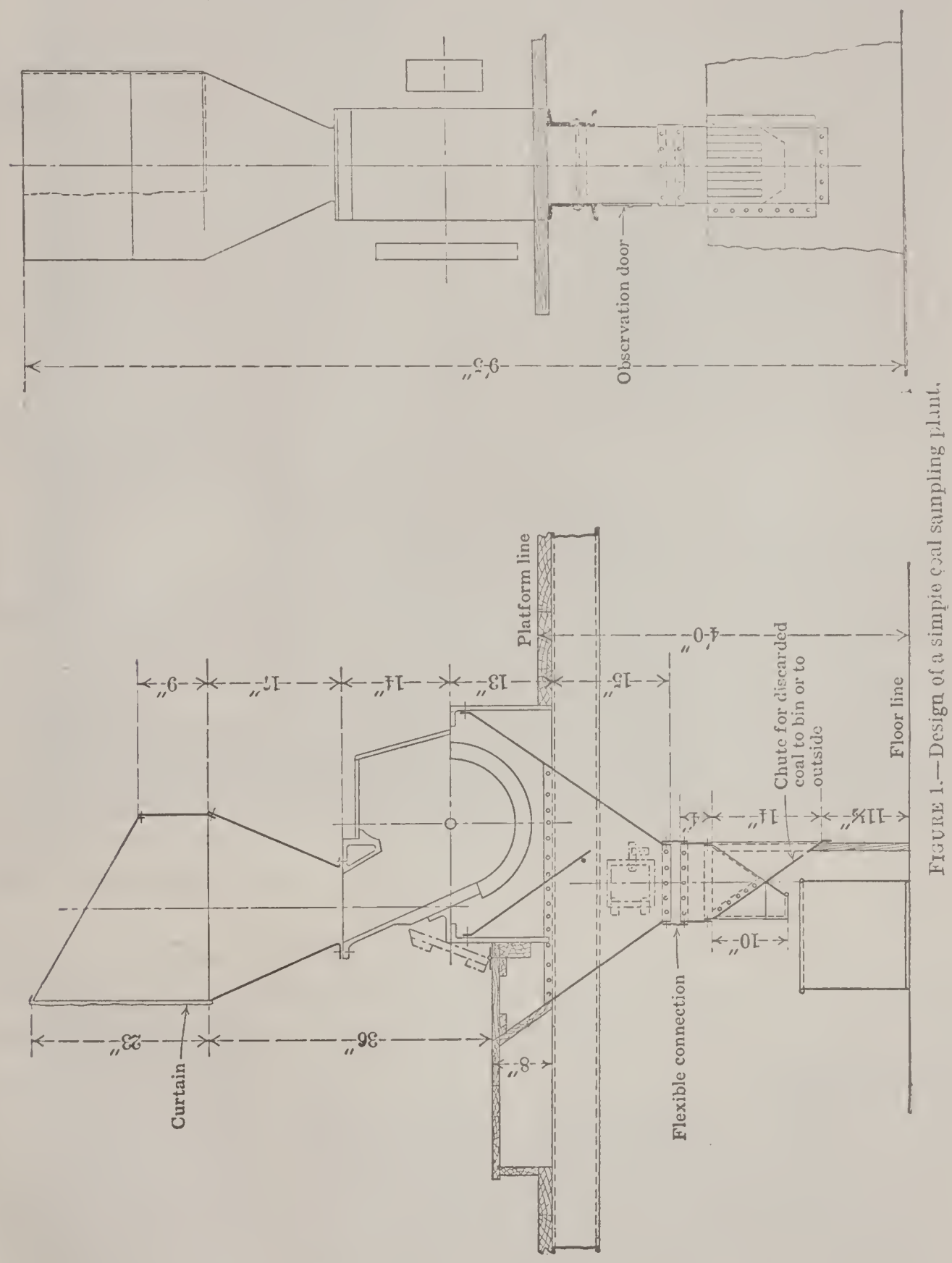


FIGURE 1.—Design of a simple coal sampling plant.

The Bureau of Mines receives from time to time requests from different branches of the Federal service for suggestions as to the type and design of installations for crushing and reducing coal samples. Plate III, *A*, is a view of a simple coal-sampling plant that is largely used by the Bureau of Mines and has been adopted by other bureaus and establishments of the Government. Figure 1 shows the design

of this plant. The riffle is constructed of channel irons and steel plates bolted together. The plan and sections of the riffle are shown in working drawings constituting figure 2. The numbers assigned to the parts shown in this figure are also shown in Plate IV, *A*. A list of the parts used in the riffle, giving the number of each required, follows:

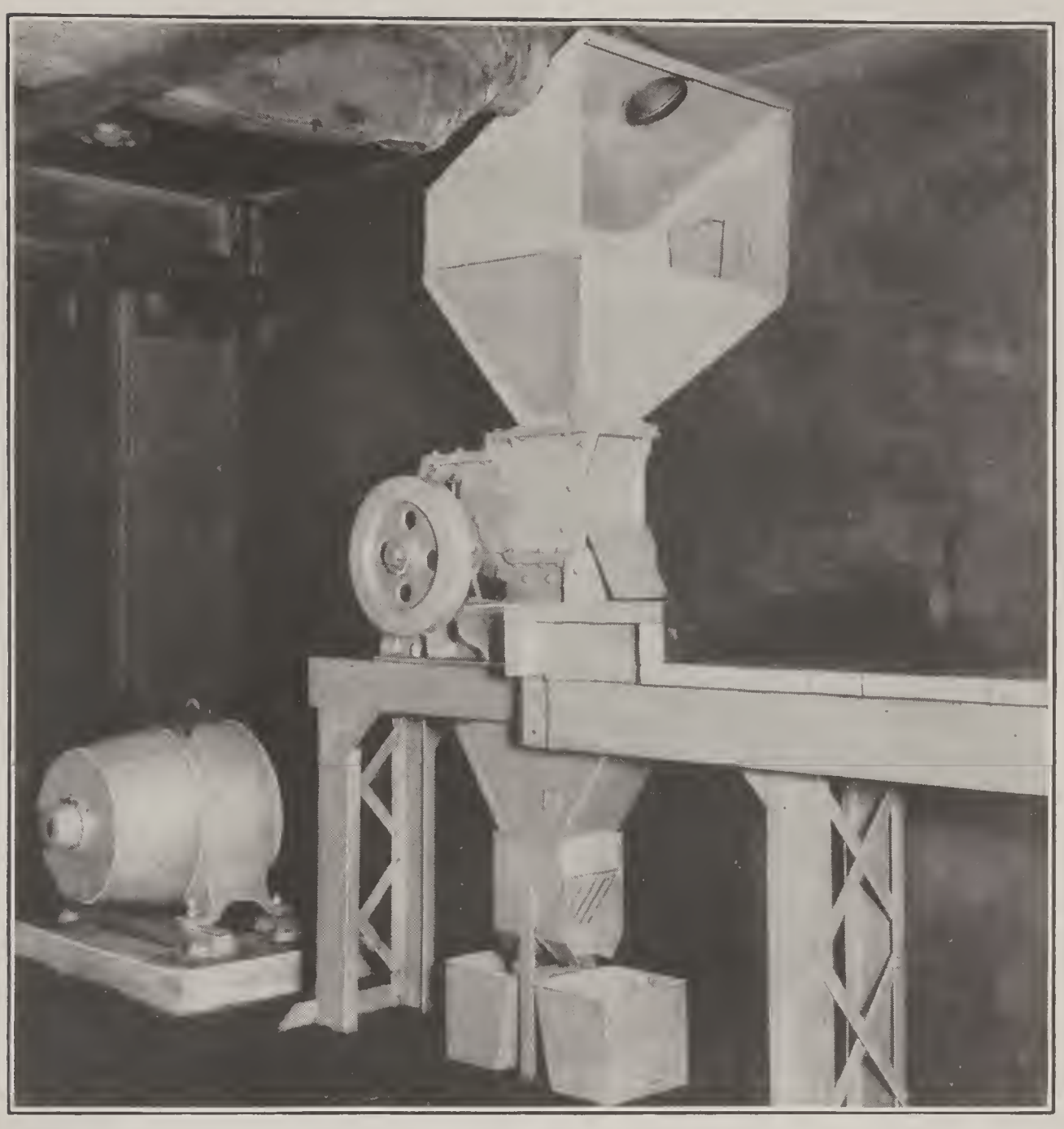
List of parts used in riffle for reducing coal sample.

Piece No.[a]	Material.	Number of pieces required.
1	$\frac{1}{16}$-inch steel plate	9
2	.....do	4
3	.....do	2
4	$\frac{3}{4}$-inch channel, $4\frac{1}{4}$ inches long	12
5	$\frac{1}{8}$-inch steel rod, $10\frac{1}{2}$ inches long	4
6	$\frac{3}{4}$-inch channel, $12\frac{3}{8}$ inches long	12
7	$\frac{1}{8}$-inch steel rod, 11 inches long	1
8	$\frac{1}{4}$-inch by 2-inch flat steel, 2 feet 2 inches long	2

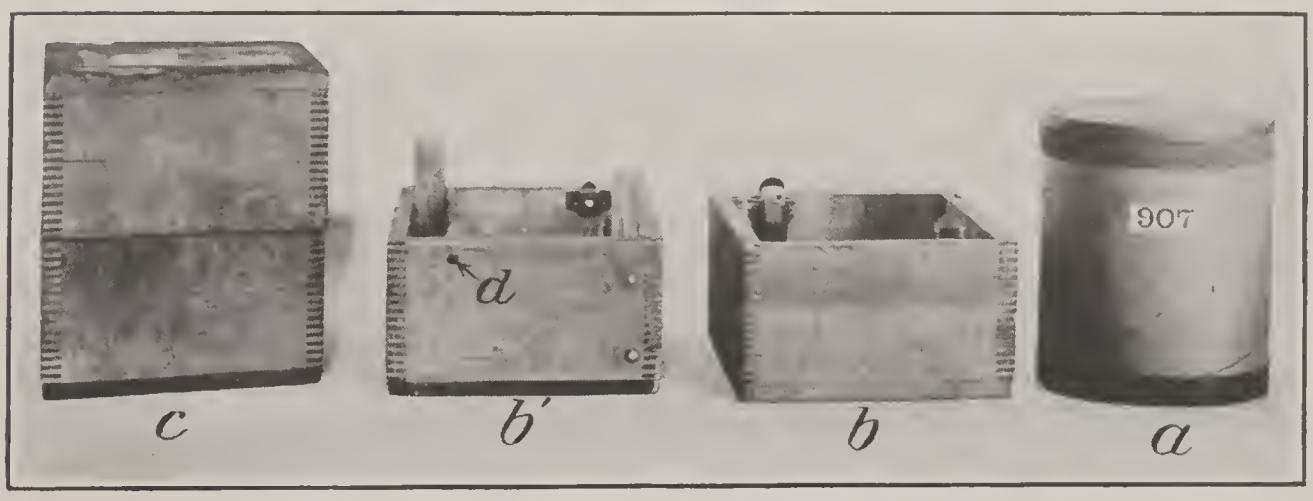
[a] See fig. 2 and Pl. IV, *A*.

The hopper, bin, and other parts through which the coal is passed are made as dust proof as possible and iron cement is used to close leaks. However, more or less free dust arises from the crusher. In the Bureau of Mines sampling plant this dust is carried away by means of a ventilating system, there being an exhaust fan, driven by a direct-connected motor, in a penthouse on the roof of the building. Galvanized-iron ducts lead from the fan to the laboratory and sampling rooms. In the sampling rooms, leading from the main ventilating duct, are branches connecting each bin and hopper, some with hoods placed over dust-producing machines. On each one of these branch ducts, as well as on the main ventilating pipe, dampers are attached by which the draught is regulated. The system is very satisfactory. It keeps the sampling rooms free from dust and prevents any from entering other parts of the building.

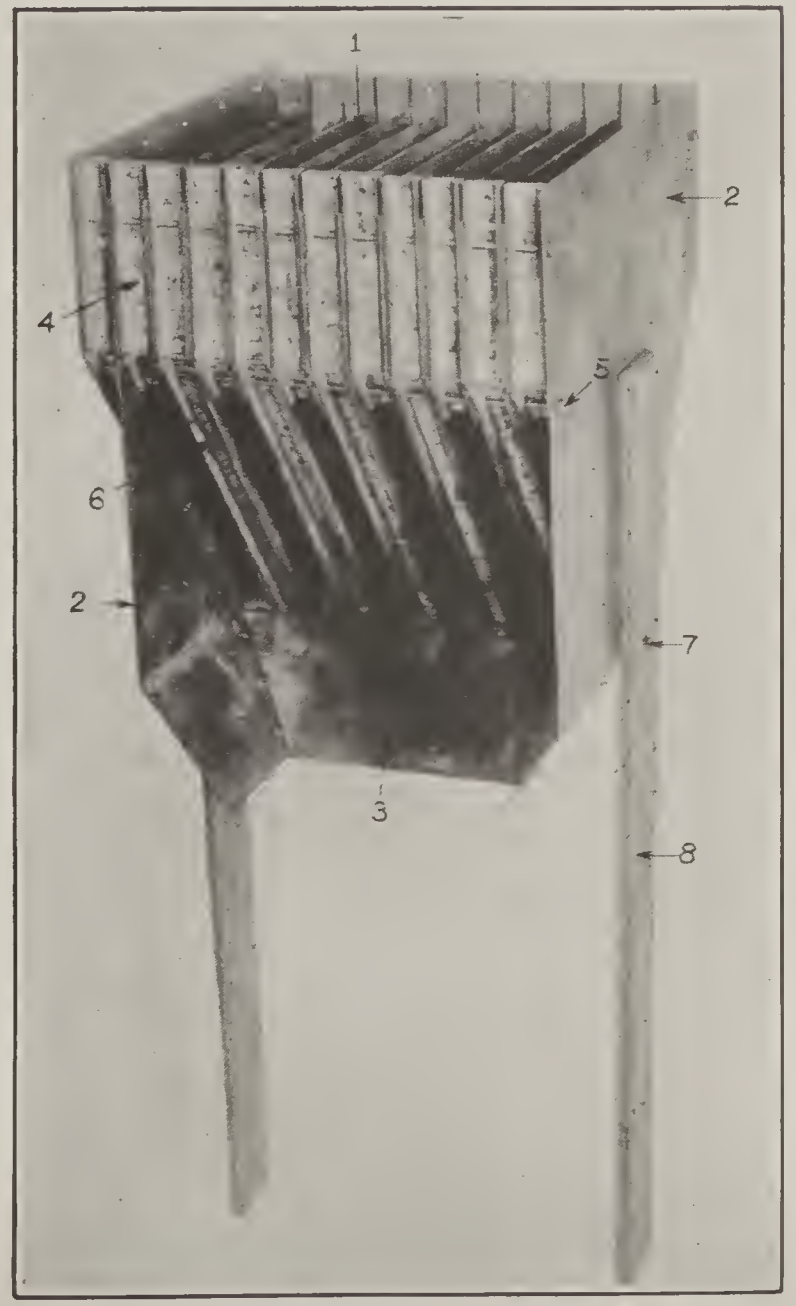
The sample is received in buckets, each holding approximately 70 pounds of coal, and the filled buckets are stored on the platform. Each bucket of coal making up the sample is successively passed through the motor-driven crusher, which reduces the coal to $\frac{3}{16}$-inch mesh and finer (practically all of the coal will pass through $\frac{1}{8}$-inch mesh), and the coal is halved by a riffle, one half being deflected to a bin for discarded coal and the other half into a bucket. As the buckets are emptied into the crusher, they are available for catching the retained half from the riffle. Buckets containing the half of the sample are easily swung to the platform and the sample is again halved in quantity by dumping the coal through the trapdoor (shown in fig. 1) and repassing it over the riffles. Elevating the sample to the platform and halving the sample are repeated until the sample is reduced to the quantity convenient for transmittal to the laboratory.



A. COAL-SAMPLING PLANT.



B. DOUBLE CONTAINER. *a*, PAPER CASE; *b*, *b'*, SECTIONS OF WOODEN BOX; *c*, CONTAINER ASSEMBLED; *d*, HOLE FOR RELEASING CATCH.



A. SAMPLING RIFFLE.

B. SEALING CONTAINER.

Only the relation of one bin wall to the riffle is shown in the drawing; the shape of the bin can be varied to suit the arrangements in the building. If the building in which the installation is housed is so situated that a chute for the discarded coal can lead directly into a wagon body, car, or the boiler room, the disposal of this coal will be simplified.

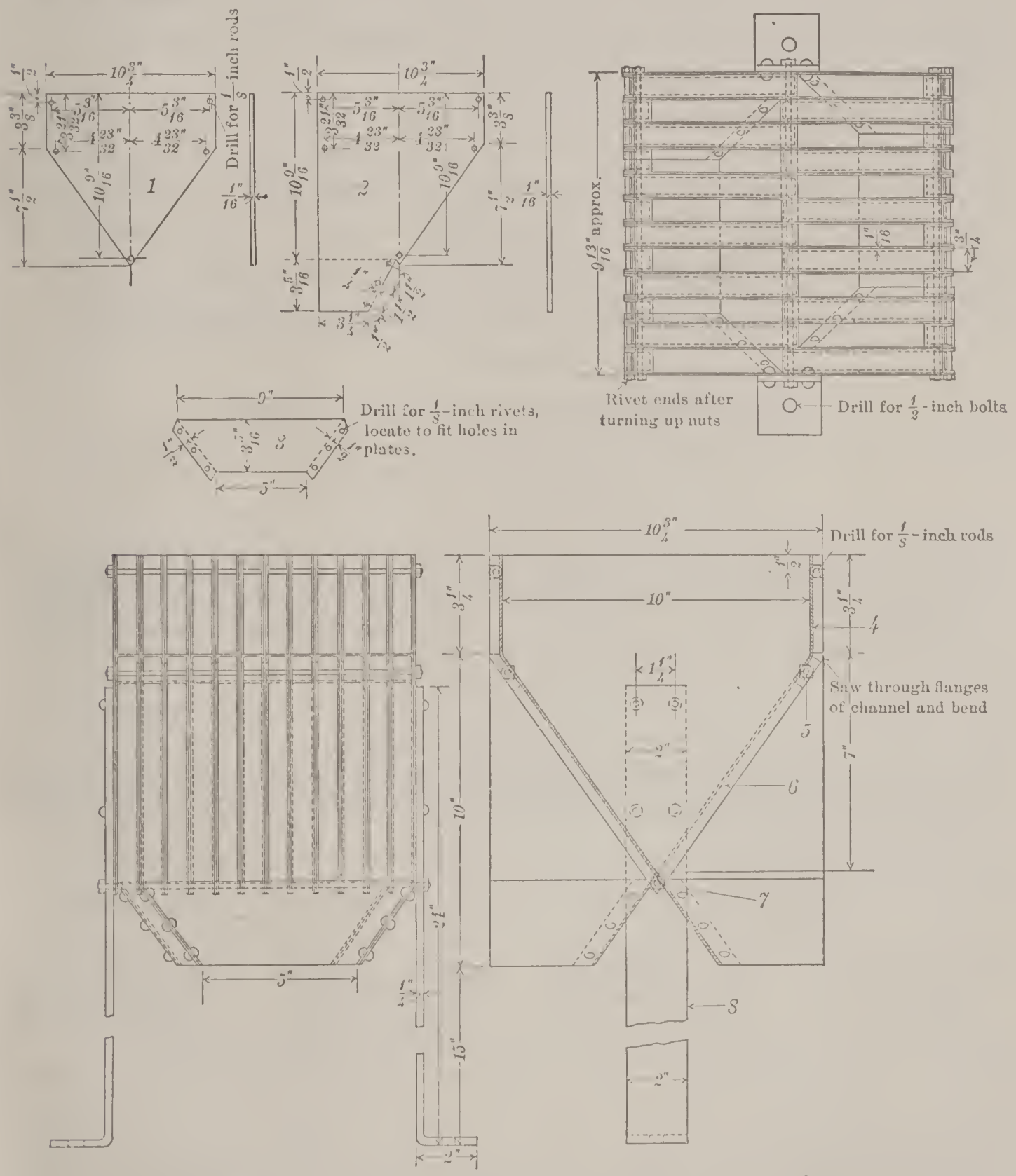

Drill for 1/8-inch rods
Drill for 1/8-inch rivets, locate to fit holes in plates.
Rivet ends after turning up nuts
Drill for 1/2-inch bolts
Saw through flanges of channel and bend

FIGURE 2.—Working drawings for riffle for reducing coal sample.

For the inspection of the riffle and the removal of matter clogging the riffle, a small door is provided in the main hopper. After each crushing the hopper and riffle should be brushed clean.

This particular form of equipment was developed with a view to simplicity and cheapness. By placing a series of riffles one below

the other, the sample can be reduced to one-quarter, one-eighth, one-sixteenth, etc., of its original quantity, depending upon the number of riffles installed. As more riffles are added, the cost is increased and the platform must be raised, requiring other means than hand labor for elevating the parts of the samples. The Bureau of Mines is experimenting with other devices and types with a view to increasing the efficiency of the installation so that it will accurately select fractional parts of the gross sample with a minimum of handling and at a relatively low cost.

All samples are reduced to a quantity that will nearly fill a 5-pound container. The samples are then in the same stage of preparation as those received from points outside of Washington, and like them are further prepared in the sampling room.[a] The methods of preparation are diagrammatically shown in the following:

Diagrams showing treatment of the 5-pound sample in the laboratory.

METHOD *A*.

5-pound sample crushed by roll crusher to 20-mesh.

5 pounds, less 3 ounces.

3 ounces immediately placed in rubber-stoppered bottle for total moisture determination only.

Successively passed through riffles and reduced to about 6 ounces. Rejected coal returned to the container and held as reserve.

6 ounces.

6 ounces ground by planetary-disk crusher to 60 mesh, passed through riffle, 3 ounces returned to reject and 3 ounces placed in a rubber-stoppered bottle. (This is the laboratory sample proper.)

1 gram (about $\frac{1}{30}$ ounce).	1 gram.	1 gram.	1 gram.
For moisture in laboratory sample.	For volatile-matter determination.	Sulphur determination by Eschka method.	For heating-value determination in a bomb calorimeter.
Ash in this 1-gram sample determined after the moisture is determined.			Sulphur is determined on the washings and residue from the calorimeter after combustion.

[a] The method of preparation of the samples in the sampling room, with a description of the laboratory methods and equipment, is given on pp. 74 to 91, Bureau of Mines Bulletin 41.

Diagrams showing treatment of the 5-pound sample in the laboratory—Continued.

METHOD *B*.

5-pound sample dried in air-drying oven for "total moisture" determination.

↓

Crushed by rolls to 20 mesh.

↓

Reduced in quantity by riffles to 8 ounces. Rejected coal returned to the container and held as reserve.

↓

8-ounce sample pulverized to 60 mesh in Abbe ball mill.

↓

8-ounce sample reduced in quantity by riffles to 3 ounces which is placed in a rubber-stoppered bottle and becomes the laboratory sample proper. Rejected coal returned to the container and held as reserve.

↓

3-ounce laboratory sample treated the same as the 3-ounce sample under method *A*.

Both methods of procedure given above are followed in the Bureau of Mines laboratory in Washington, D. C., wherein the samples representing Government coal deliveries are analyzed and tested—method *B* being followed for most anthracite samples and for any samples of high-moisture or wet coals, as by this method a more representative moisture value can be obtained than by method *A*, for in method *A* high-moisture or wet coals unavoidably lose more or less moisture in the crushing of the 5-pound sample. Method *B*, somewhat modified,[a] is followed on all samples in the Bureau of Mines laboratory in Pittsburgh, Pa., which is maintained for analyzing and testing samples necessary for the conducting of certain fuel, mining, and metallurgical investigations which the bureau is making.

SEALING AND MAILING.

The final 5-pound sample is immediately placed in the container furnished by the Bureau of Mines and sealed air-tight. The coal should be firmly packed in the container, so as to occupy as much of the space as possible, as in this way the air is more nearly excluded. This packing is best accomplished by having the coal finely crushed in the manner described in the preceding pages and by shaking or jarring the container repeatedly and vigorously while filling it.

[a] Stanton, F. M., and Fieldner, A. C., Methods of analyzing coal and coke: Tech. Paper 8, Bureau of Mines, 1913, 42 pp.

Two coal-sample containers have been developed by the Bureau of Mines, one a galvanized iron can and the other a double container, consisting of a wooden shipping box and an inclosed pressed-paper case.

The metal can is 11 inches long and $3\frac{1}{8}$ inches in diameter (inside dimensions), with a screw cap 2 inches in diameter. Its edges are crimped and carefully soldered, so as to make it air-tight and strong. The screw cap has a washer of rubber, or other flexible material, to exclude the air. As a further protection and to insure tightness, the cap, when in place and screwed down, is wrapped carefully with several layers of adhesive tape, the first layer of which completely covers the joint between the lower edges of the cap and the neck of the can. In Plate IV, *B*, *a* shows the first layer of the tape being forced down with thumb and forefinger, and *b*, the can properly sealed. It is not advisable to use solder, paraffin, or sealing wax of any kind, because some of the material may become mixed with the coal, either when it is applied or when the cap is removed. Before it is filled, each can should be carefully inspected as to tightness and freedom from rust.

The capacity of the can is $2\frac{1}{2}$ to 3 pounds of coal, and as the quantity required for transmittal to the laboratory is 5 pounds, two of the cans are used for each sample. After the sample has been reduced to a quantity that will about fill two cans, it should be thoroughly mixed and divided into two parts and one put in each can. Bureau of Mines Form 6–220, used for furnishing data concerning the sample (p. 38) is filled in for each can, and the form is placed (not pasted) around the can. Each form shows the number of the can which carries the other half of the sample. As a safeguard against the can opening in transit and the coal damaging the contents of a mail sack, each can is wrapped with several thicknesses of heavy manila paper. An addressed franked wrapper is pasted on or tied around the wrapped can.

The double container is shown in Plate III, *B*, in which *a* is the pressed "damptite" paper case, *bb'* the two sections of the wooden box; *c* is the container assembled.

The box is opened by inserting a nail, or any pointed instrument, in the two holes in opposite sides of the box (one being shown, *d*). This pointed instrument should not be inserted too far, as it would perforate the paper case, but only far enough to release the spring catches which hold the two halves of the box together, so that the upper half of the box can be lifted off.

The pressed paper case is $5\frac{7}{8}$ inches total diameter and 7 inches long over all, and has a capacity of 5 to 7 pounds of coal. The shipping box is made of sound, well-seasoned basswood, free from knots, checks, and doaty places, and is made strictly in accordance with

specifications, as regards thickness of the material, number of nails, inside dimensions, arrangement of corners, catches, finish, etc. The corners are made lock-jointed, each being glued throughout its full length by dipping the joints in glue before assembling. They are further reinforced by small finishing nails driven through the tenons of each corner, so that the box is thoroughly substantial. One part of the box has two corner blocks of specified dimension and form, which are glued through their length into the corners of the box and riveted. Two special suit-case catches are used, which are placed on the inside of the box near opposite corners and so situated that they will operate in either of the two possible ways of assembling the box. The small holes are so drilled through each side of the box and through the small part of the catch lug that the catches are readily released when a pointed instrument is inserted in the holes.

The sample of coal is placed in the paper case, and the edge of the cap is wrapped with electrician adhesive tape so as to seal the paper case as nearly air-tight as possible. Form 6–220, properly filled in with data concerning the sample, is placed (not pasted) around the case, and the case is then placed in the box and the box assembled. An addressed shipping tag is pasted or tacked onto the box.

The blank form referred to is in two sections—an original and a duplicate. The original form accompanies the sample, furnishes the bureau complete information as to the sample, and becomes the bureau's permanent record. The duplicate is used as a file copy for the office submitting the sample.

Special attention should be given to filling out the form and promptly forwarding the sample. Failure to fill out the form properly or to place it around the container may cause indefinite delay in making the analysis of a sample and in reporting the results.

A letter should be written informing the bureau that a sample or samples (container numbers stated) have been forwarded. As the tonnage on many orders or deliveries during a month may be considerable, and as samples may be submitted from time to time, unless the bureau is informed it has no knowledge whether all samples have been received to represent the tonnage, nor has it any intimation as to which is the first or last sample, although this information is necessary to insure prompt reports. To furnish the necessary information, it should be stated in the letter, as follows:

This is the first and only sample which will be submitted on order No. ——, or of the deliveries during the month of ———.

Or,

This sample is the —— (give number) one submitted on order No. ——, or of the deliveries during the month of ———, and other samples on this order or month's delivery will be submitted.

Or,

This is the last sample on order No. ————, or of the deliveries during the month of ————, and is to be considered with samples submitted in containers numbered ———.

If a sample is submitted representing coal from a mine or from a source other than that specified in the contract, the letter transmitting the sample should so state, in order that the records of the Bureau of Mines will be complete.

A copy of the front and reverse sides of the two sections comprising the form mentioned above are herewith given.

[Original, front.]

6-220 DEPARTMENT OF THE INTERIOR.

BUREAU OF MINES.

Coal delivered to .....
(Institution. If ship or barge, state where loaded.)
Container number ..... Sample number.....
(Serial number of institution mailing sample.)
Name of contractor .....
Coal, kind and size .....
Number of tons represented by this container .....
Date of delivery ..... Date of mailing sample .....
Contract number ..... Order number .....
Is this the only sample on this order or month's delivery? .....
(Answer yes or no.)
If not, is this the first, second, etc., or last sample? .....
If this is the *last* of several samples, state total tonnage delivered under this order or month's delivery .....tons.
Original. (Signed) .....

[Original, back.]

SUGGESTIONS AS TO FILLING AND SEALING CONTAINERS.

The coal sample should be firmly packed in the container so as to occupy as much of the space as possible, since in this way the air is more nearly excluded. To insure the tightness of the container, the cap when in place should be wrapped carefully with several layers of adhesive tape, the first layer of which should completely cover the joint between the lower edge of the cap and the neck of the container. It is not advisable to use solder, paraffin, or sealing wax of any kind, because some of the material may be mixed with the coal either when the material is applied or when the cap is removed. Before being filled each container should be carefully inspected as to tightness and freedom from foreign matter. Any containers rendered defective in transit should be returned empty. The Bureau of Mines will furnish a supply of containers and of this form on request.

[For instructions as to use of this form, see instructions on back of attached (duplicate) section.]

[Duplicate, front.]

6-220

DEPARTMENT OF THE INTERIOR.

BUREAU OF MINES.

Coal delivered to.....
(Institution. If ship or barge, state where loaded.)
Container number..... Sample number.....
(Serial number of institution mailing sample.)
Name of contractor.....
Coal, kind and size.....
Number of tons represented by this container.....
Dates of delivery..... Date of mailing sample.....
Contract number..... Order number.....
Is this the only sample on this order or month's delivery?.....
(Answer yes or no.)
If not, is this the first, second, etc., or last sample?.....
If this is the *last* of several samples, state total tonnage delivered under this order or month's delivery.....tons.
Duplicate. (Signed).....

[Duplicate, back.]

INSTRUCTIONS AS TO THE USE OF THIS FORM.

Fill out this form for each sample of coal forwarded to the Bureau of Mines. The office filling out the form is to retain the *duplicate* copy. The original must be placed around the container (but not pasted to the container; it may be held in place by a rubber band) in such a manner that the sample and the information regarding it can not be separated in mailing. This form must be properly filled out and forwarded in order to expedite testing and reporting. A letter should be written informing the bureau that sample or samples (giving container numbers) have been forwarded. The receipt of the sample will be immediately acknowledged.

[For suggestions as to filling and sealing containers, see back of attached (original) section.]

REPORTING ANALYSES.

The analyses and tests of samples are reported by the laboratory to the fuel-inspection section, where the record of the samples is kept. The laboratory receives the samples with an identification number only, which is given the sample when the sample is received from the mail, and the laboratory reports the analysis and test by number only. If a report is to be based on the analyses of two or more samples, the analyses are averaged, each analysis being given a weight according to the proportion of the total tonnage which it represented. The results are then reported in triplicate on the following letter form to the branch of the service submitting the sample or samples, which in turn furnishes the contractor one of the copies:

DEPARTMENT OF THE INTERIOR.

BUREAU OF MINES.

Washington, D. C., ...

SIR: In reference to the..... tons of ..... coal delivered on your contract No. ..... and your order No. ..... to the..... ....., 191 , by.....

The analysis of the samples of coal received by the Bureau of Mines was as follows:

	As received.	Dry coal.
Moisture.....		
Volatile matter.....		
Fixed carbon.....		
Ash.....		
Total		
Sulphur.....		
British thermal units.....		

This information is for the use of the Government and the dealer or operator furnishing the coal. It i confidential until it is published by the United States Government.

Remarks:

Certified: Respectfully,

....

Engineer in charge Fuel Inspection. *Director.*

COAL SPECIFICATIONS AND PROPOSALS.

There are given in the following pages coal specifications and proposals typical of those in use by the Government for the purchase of coal under specifications based on the heating value, the content of ash and of moisture, and other considerations.

The method for sampling[a] is not printed as an integral part of the specifications, but as a separate appendix. It is published in a larger edition than the specifications, so that all officials charged with the duty of collecting samples may be supplied with copies.

Two classifications of the coal purchased are made, namely, (*a*) coal for steam power and heating plants, which include bituminous (semibituminous, subbituminous, lignite) and the small sizes of anthracite (pea and buckwheat), and (*b*) the large sizes of anthracite (broken, egg, chestnut, and stove), which are used in small house-heating furnaces and stoves for heating and domestic uses.

The purpose of the specifications is to clearly set forth the character and quality of coal desired, to obtain bids which fully specify

[a] The Government method of sampling coal is quite similar to the tentative standard method of the American Society for Testing Materials (Am. Soc. Testing Materials: Yearbook, 1915, p. 591).

the coal offered, the values offered in the case of power and heating coals by the successful bidder becoming a part of the contract, to furnish means whereby the Government may be assured of receiving the coal contracted for, providing for a definite procedure for determining equitable settlement for coals differing in character and quality, and to include concise statements of the necessary legal phases, etc., all with the view that the specifications and proposal signed by the successful bidder may become a contract which will work to the advantage and justice of both the Government and the contractor.

Attention is especially directed to instructions for sampling given in the specifications which become a part of the contract. Prior to the fiscal year 1912–13 the method of sampling was given scant mention, leaving one of the most important features determining the successful and satisfactory application of the specification method of the purchase of coal almost wholly in the hands of the purchaser, the seller having little or no means whereby he could exercise a control of the manner and method of collecting and preparing samples that should represent the coal furnished. It is as essential that an established and an agreed-upon method of sampling be followed, as it is that the sample be analyzed by a reputable laboratory; in fact, the sampling is of first consequence, for if a sample is haphazardly taken and carelessly reduced to a quantity convenient for transmittal to the laboratory, and hence is nonrepresentative, it is usually impossible or impracticable to get another sample; whereas if the analysis and test of a representative sample are in error, the remaining part of the sample can be analyzed and tested, by another laboratory if desired. Unwarranted corrections in price and resulting injustice and hardship to the buyer or seller may easily and unintentionally occur through lack of perception of the relative importance of sampling and the observance of proper methods of collecting and preparing samples. By clearly setting forth the method of sampling as a part of the contract, the seller or the buyer has something tangible on which to base legitimate complaints if samples are not properly collected and prepared. Such is the purpose of putting in the Government specifications the method of sampling in some detail.

As the specifications given herein are so general, applying generally to all coals purchased by the Government under every condition of delivery, it is impossible to state therein more specific directions for sampling, but for any particular conditions of delivery more definite directions can be prepared and proper consideration for the character of the coal given. By observance, however, of the general directions for sampling, which are given in the specifications that follow, samples

that are fairly representative of the coal sampled can be obtained without difficulty.

Though a contract may be let under the specification basis, the sampling of small orders of, say, 50 tons or less, may be discretionary with the Government, a provision to this effect appearing in the contract. If samples are not taken the bid price per ton is paid. This discretionary right of sampling small orders or tonnages makes it unnecessary to sample small deliveries under one large general contract of from a half to a few tons to small launches or boats, or to different quarters or buildings where facilities for sampling or storing accumulated samples are not at hand. It is obvious that the expense of collecting and preparing a sample to represent such small tonnages, together with the cost of analysis, would make the unit cost per ton ordinarily prohibitive and disadvantageous.

Under "Price and Payment" for bituminous coal (p. 51), 2 per cent variation from the guaranteed standard of British thermal units (B. t. u.) is allowed before price corrections. On 14,000 B. t. u., "dry coal," this means that there is no price correction for delivered coal of an apparent heating value as reported by the laboratory between 13,720 and 14,280. This is allowed to provide (*a*) for the reasonable variations that, it is recognized, may be obtained with the same 5-pound sample in two different determinations in the same laboratory, (*b*) for variations that result in preparing and reducing the gross sample to a quantity convenient for transmittal to the laboratory, (*c*) for variations due to the collection of gross samples as representing the coal sampled, and (*d*) for allowing the contractor latitude in the preparation of the coal, as it is recognized that the quality of his coal expressed in terms of ash and B. t. u. can not be controlled within strictly narrow limits.

In interpreting a heating value determination, then, the value reported by the laboratory must be considered as the apparent value of the coal sampled, as the actual value of the coal may have been more or less than the apparent value because of the variations above cited. If the reported value differs by more than 2 per cent from the guaranteed standard, the result is considered as evidence that coal of a quality other than that contracted for was delivered and the price is corrected accordingly. If a number of gross samples are taken to represent a total quantity of coal delivered, and a report is obtained by averaging the several analyses and tests, the apparent value reported by the laboratory may be within 1 per cent or less of the actual value of the entire quantity, but in specifications as general as those given herein a 2 per cent variation from the standard is considered more equitable and will eliminate frequent and unwarranted price corrections, especially if payment for a delivery or order is based on a single determination. In the sampling of cargo shipments to the

Isthmus of Panama (p. 19) the reported results between two separate and independent series of samples representing the same cargo agree on an average within less than 50 B. t. u. The samples are collected by experienced collectors and prepared very systematically, and the reported results for a cargo are determined by averaging a number of analyses. With such sampling the variations above enumerated are largely averaged and eliminated, and the variation that may be allowed before price corrections may, under such conditions, be reduced to 1 per cent or even less.

It is not the intent of the specifications continually to make corrections in price for slight variations of the actual heating value from the guaranteed standard, and it is desired to eliminate corrections which are unwarranted because of the difference between the reported apparent heating value and the actual heating value, the first purpose of the specifications being to insure that the Government is receiving coal similar within reasonable limits to the standard of the contract.

The power and heating plant specifications require the bidder to specify the quality of coal offered in terms of moisture, "as received," ash, sulphur, volatile matter, and B. t. u., "dry coal;" these values becoming the standards of the contract to determine rejectable coal and the price to be paid for delivered coal. Bidders have in some cases specified a higher B. t. u. value and a lower ash content than the quality of the coal warranted, upon the theory that the high B. t. u. and low ash values would give them an advantage in the comparison of bids. The bid price may be correspondingly higher, the bidder presumably expecting a deduction to be made and to receive a price on his delivered coal lower than the bid price. The apparent price may be, therefore, higher than the actual price received, and use may be made of the apparent price for advertising purposes. Bidders are cautioned against offering higher standards than can be maintained on an average, for to do so may result in the bid being rejected (see sec. 8, p. 47, of the specifications), or may result in excessive penalties, the purchase of coal in the open market, the difference in cost of coal so purchased being charged against the contractor, or may lead to the cancellation of the contract (see sec. 30, p. 50).

By reference to the specifications for anthracite, broken, egg, stove, and chestnut sizes, it will be noted that bidders are not required to specify the quality of the coal in terms of ash, B. t. u., moisture, sulphur, and volatile matter, and that regular and systematic sampling of all deliveries is not required to determine the price to be paid for each and every delivery. The specifications provide, however, for the sampling of coal that proves unsatisfactory because of excessive ash or clinkering and for price corrections if the ash as shown by analysis is in excess of a permitted variation from the standard

for the particular size of coal, these standards being determined from hundreds of ash determinations made during a period of six years. B. t. u. standards are not used, as it has been determined that the heating value for the different sizes is, in the main, a function of the ash content, varying inversely and in proportion with the ash; that is to say, if the ash content is increased, for example, 1 per cent, the heating value is decreased 1 per cent.

Because of economic considerations and the physical character of anthracite, the specifications used for bituminous and the small sizes of anthracite coal requiring sampling are not adapted for the purchase of the large sizes of anthracite. Most of the Government contracts for these sizes are for relatively small yearly tonnages with deliveries of ½ ton to 50 tons, but seldom more to a building. To collect regularly samples from such small deliveries would make the unit cost per ton of sampling prohibitive, the cost being generally greater than any probable saving. To obtain samples that would fairly represent the quality of these coals would require collecting samples of 1,000 to 1,500 pounds, or more, and to obtain a final sample for analysis that would represent the gross sample within reasonable limits would require crushing and recrushing the gross sample, thereby perhaps destroying the value of the gross sample for use in a house-heating furnace or stove, and largely wasting it, unless a Government steam-power plant were available in which it could be advantageously burned. The total or partial loss in value of 1,000 or 1,500 pounds of coal at $5 to $10 per ton from a small delivery is manifestly a matter deserving consideration. Owing to the hardness and brittleness of anthracite, the crushing of a gross sample by hand is difficult and tedious and requires hours of labor; in fact, a mechanical means of crushing is almost absolutely necessary, but the cost of the necessary equipment would prove prohibitive in the case of small contracts.

Because of the above facts, as well as the manner in which anthracite is prepared at the colliery and the small area of the Pennsylvania anthracite fields, and because of other considerations, the Government does not consider the application of the specifications which are adapted for bituminous coal generally suitable for the purchase of the large sizes of anthracite. The specifications that are used provide for the acceptance and use of coal and payment at contract price so long as no difficulty is experienced, and the collection of samples is necessary only as set forth in the specifications.

Anthracite is graded into sizes before shipment, and each grade commands a certain price. The size of the openings in screens and the types of screens used in preparing the sizes may vary slightly; however, the following table indicates the commercial sizes of anthracite:

Sizes of anthracite.

Sizes.	Prepared with square-mesh screens.		Prepared with round-mesh screens.	
	Through meshes having opening of—	Over meshes having opening of—	Through meshes having diameter of—	Over meshes having diameter of—
	Inches.	*Inches.*	*Inches.*	*Inches.*
Broken (furnace)	4	2¾	4½	3¼
Egg	2¾	2	3¼	2¼
Stove	2	1⅜	2¼	1½
Nut (chestnut)	1⅜	¾	1½	⅞
Pea	¾	½	⅞	9/16
Buckwheat No. 1	½	¼	7/16	5/16
Buckwheat No. 2, or rice	¼	⅛	5/16	3/16
Buckwheat No. 3, or barley	.....	.....	3/16	1/16

SPECIFICATIONS AND PROPOSALS FOR BITUMINOUS AND ANTHRACITE COAL.

.....
(Office issuing the proposals.)

.....
(Place.)

.....
(Date.)

I. PROPOSALS.

Date to be delivered.

1. Sealed proposals, in duplicate, on blank forms supplied by the ....., to furnish such quantities of coal as specified herein as may be required for use of the ....., for the fiscal year ending June 30, 191.., will be received until 2 o'clock p. m., ..., at the office of the ....., and then opened.

Bidder may be present.

2. Each bidder shall have the right to be present, either in person or by attorney, when the bids are opened.

Address of proposals.

3. Proposals, in duplicate, must be forwarded to the..... ....., postage prepaid. Addressed envelope for mailing is inclosed herewith.

Form and signature.

4. Proposals must be made in duplicate on the form given herein, and must be signed by the individual, partnership, or corporation making the same; when made by a partnership, the name of each partner must be signed. If made by a corporation, proposals must be signed by the officer thereof authorized to bind it by contract, and be accompanied by a copy, under seal, of his authority to sign.

Cash or certified check.

5. The proposals must be accompanied by cash or by certified check drawn payable to the order of the ....., in the amount equal to 2 per cent of the estimated amount involved for the fuel for which bids are submitted, the minimum amount in any case to be $10. This requirement is solely to guarantee, if the award is made on the proposal, that within 10 days after notice is given that an award has been made, the bidder will enter into a contract in accordance with the terms of the proposal and execute a bond for the faithful performance thereof, with good and sufficient sureties as hereinafter required. In the event of the failure of the bidder to enter into contract or execute bond, the cash or check guaranty will be forfeited.

II. CONTRACTOR'S BOND.

Sureties.

6. Each contractor shall be required to give a bond, with two or more individual sureties or one corporate surety duly qualified under the act of Congress approved August 13, 1894, in which the contractor and the sureties shall covenant and agree that, in case the said contractor shall fail to do or perform any or all of the covenants, stipulations, and agreements of said contract on the part of the said contractor to be performed as therein set forth, the said contractor and his sureties shall forfeit and pay to the United States of America any and all damages sustained by the United States by reason of any failure of the contractor fully and faithfully to keep and perform the terms and conditions of

his contract, to be recovered in an action at law in the name of the United States in any proper court of competent jurisdiction. Such sureties (except corporate sureties) shall justify their responsibility by affidavit showing that they severally own and possess property of the clear value in the aggregate of double the amount of the above-mentioned forfeiture over and above all debts and liabilities and all property by law exempt from execution; the affidavit shall be sworn to before a judge or a clerk of a court of record or a United States attorney, who must certify of his own personal knowledge that the sureties are sufficient to pay the full penalty of the bond.

May be waived.

7. If the estimated amount involved in the contract does not exceed the sum of $200, then the bond may be waived with the consent of the department involved.

III. RESERVATIONS.

Rejection of bids.

8. The right is reserved by the Government to reject any and all bids and to waive technical defects. Bidders are cautioned against guaranteeing higher standards of quality than can be maintained in delivered coal (this applies especially to bituminous coal and the steam sizes of anthracite), as the Government reserves the right to reject any and all bids, if the Government has information regarding analyses and test results that indicate that higher standards have been offered than probably can be maintained.

Tests.

9. The right shall be reserved by the Government to purchase for the purpose of making boiler tests other coal than that herein contracted for, provided the amount so purchased shall not exceed 10 per cent of the estimated consumption during the period covered by this agreement.

Lowest bids may not be considered.

10. If it should appear to be to the best interests of the Government to do so, the right is reserved to award the contract for supplying coal at a price higher than that named in a lower bid, or in lower bids.

Failure to contract.

11. If the bidder to whom the award is made shall fail to enter into a contract as herein provided, then the award may be annulled and the contract let to the next most desirable bidder without further advertisement, and such bidder shall be required to fulfill every stipulation expressed herein, as if he were the original party to whom the contract was awarded; provided, however, that such bidder is notified of said award within 60 days after the date on which the bids on this contract were opened. If such notice should not be given within said 60 days, then the acceptance of the award will be optional with the said bidder.

Contracts nontransferable.

12. No contract can be lawfully transferred or assigned.

Default.

13. No proposal will be considered from any person, firm, or corporation in default of the performance of any contract or agreement made with the United States, or conclusively shown to have failed to perform satisfactorily such contract or agreement.

IV. QUANTITY.

14. The estimated quantity of coal in ..... tons of 2,000 pounds to be purchased is based upon the previous annual consumption, but the right will be reserved to order a greater or less quantity, subject to the actual requirements of the service.

V. DELIVERY.

Quantity, time, and place. 15. The coal shall be delivered in such quantities at such times as the Government may direct. (Place of delivery to be stated.)

Rapidity. 16. All the available storage capacity of the Government coal bunkers shall be placed at the disposal of the contractor to facilitate delivery of coal under favorable conditions. When an order is issued for coal, the contractor upon commencing a delivery on that order shall continue the delivery with such rapidity as not to waste unduly the services of the Government inspector.

Failure to deliver. 17. After verbal or written notice shall have been given to deliver coal under this contract a second notice may be served in writing upon the contractor to make delivery of the coal so ordered within a reasonable time, to be determined by the Government official in charge, after receipt of said second notice. Should the contractor for any reason fail to comply with the second request, the Government shall be at liberty to buy coal independent of this contract, and for coal so purchased to charge against the contractor and his sureties any excess in price over the price which would have been paid to the contractor had the coal been delivered by him.

Hours. 18. The contractor shall be allowed to deliver coal during the usual hours of teaming—that is, between 8 a. m. and 5 p. m.

Weighing. 19. (To be stated by whom and where the coal shall be weighed, etc.)

VI. SAMPLING.

Contractor privileged to be present. 20. The contractor shall have the privilege of having a representative present to witness the collection and preparation of the samples to be forwarded to the laboratory.

Method. 21. The samples shall be collected and prepared in accordance with the method given in Appendix A, attached hereto as a part of these specifications and proposals.

VII. ANALYSES.

Laboratory and thod. 22. The samples shall be immediately forwarded to the Bureau of Mines, Department of the Interior, Washington, D. C., and they shall be analyzed and tested in accordance with the method recommended by the American Chemical Society and by the use of a bomb calorimeter. Such analyses and tests shall be made at no cost to the contractor. The results shall be reported by the Bureau of Mines in not more than fifteen (15) days after the receipt of the sample. If more than one sample is received from the same delivery, the fifteen (15) days shall date from the receipt of the last sample taken.

VIII. BITUMINOUS AND ANTHRACITE PEA AND BUCKWHEAT COAL FOR POWER AND HEATING PLANTS.

DESCRIPTION OF COAL DESIRED.

Kind and quality. 23. The coal must be a good coal..... (kind and size to be specified), and must be adapted for successful use in the particular furnace and boiler equipment.

Information to be supplied by bidder. 24. Bidders are required to specify the coal offered in terms of moisture in the coal "as received," and of ash, volatile matter, sulphur,

and British thermal units in "dry coal," such values to become the standards for the coal of the successful bidder. In addition, the bidders are required to give the trade name of the coal offered, the name or other designation of coal bed, name of mine or mines, location of mine or mines (town, county, and State), railroad on which mine or mines are located, and name of operator of mine or mines. This information shall be furnished in spaces provided hereinafter.

NOTE.—Bids not supplying the foregoing information may be considered informal and rejected.

Coal of the description and analysis specified is herein known as coal of the contract grade. Bidders are cautioned against specifying higher standards than can be maintained, for to do so will result in deductions in price and may result in the rejection of delivered coal or the cancellation of the contract. In this connection it should be recognized that the small "mine samples" usually indicate a coal of higher economic value than that actually delivered in carload lots, because of the care taken to separate extraneous matter from the coal in the "mine samples."

AWARD.

Considerations.

25. In determining the award of this contract consideration will be given to the quality of the coal (expressed in terms of moisture in coal "as received," of ash in "dry coal," and British thermal units in "dry coal") offered by the respective bidders and to the operating results obtained with the same and with similar coals on previous contracts or by test, as well as to the price per ton.

Bids subject to rejection.

26. Bids may be rejected from further consideration if they offer coals regarding which the Government has information that they possess unsatisfactory physical characteristics or volatile matter or sulphur or ash contents, or that they are unsatisfactory because of clinkering or excessive refuse, or because of having failed to meet the requirements of city smoke ordinances, or for other cause that would indicate that they are of a character or quality that the Government considers unsuited for the storage space or the furnace equipment of the particular contract.

Method of comparing bids.

27. In order to compare bids as to the quality of the coal offered, all proposals shall be adjusted to a common basis. The method used shall be to merge the four variables—moisture content, ash content, heating value, and price bid per ton—into one figure, the cost of 1,000,000 British thermal units. The procedure under this method shall be as follows:

(*a*) All bids shall be reduced to a common basis with respect to moisture, by dividing the price quoted in each bid by the difference between 100 per cent and the percentage of moisture guaranteed in the bid. The adjusted bids shall be figured to the nearest tenth of a cent.

(*b*) The bids shall be adjusted to the same ash percentage by selecting as the standard the proposal that offers coal containing the lowest percentage of ash. The difference in ash content between any given bid and this standard shall be divided by 2 and the price in such bid, adjusted in accordance with the above, multiplied by the quotient. The result shall be added to the above adjusted price. The adjusted bids shall be figured to the nearest tenth of a cent.

(*c*) On the basis of the adjusted price, allowance shall then be made for the varying heat values by computing the cost of 1,000,000 British thermal units for each coal offered. This determination shall be made by multiplying the price per ton adjusted for ash and moisture contents by 1,000,000, and dividing the result by the product of 2,000 multiplied by the number of British thermal units guaranteed. If the coal is purchased on the basis of 2,240 pounds to the ton, the factor of 2,240 should be used instead of 2,000.

Service test.

28. After the elimination of undesirable bids, the selection of the lowest bid of those remaining on the basis of the cost per 1,000,000 British thermal units may be considered by the Government as a tentative award only, the Government reserving the right to have practical service test or tests made under the direction of the Bureau of Mines, the results to determine the final award of contract. The interested bidder or his authorized representative may be present at such test.

CAUSES FOR REJECTION.

Coal subject to rejection.

29. It is understood that coal containing 3 per cent more moisture, or 4 per cent more ash, or 3 per cent more volatile matter, or 1 per cent more sulphur, or 4 per cent fewer British thermal units than the specified guaranties as to the standards for the coal hereunder contracted for, or coal furnished from a mine or from mines other than herein specified by the contractor, unless upon written permission of the Government, shall be considered subject to rejection, and the Government may, at its option, either accept or reject the same. Should the Government have consumed a part of such coal subject to rejection, such consumption shall not impair the Government's right to cause the contractor to remove the remainder of the delivered coal subject to rejection.

Cancellation of contract—open market purchases

30. It is agreed that if the contractor shall furnish coal in three consecutive deliveries, or in case more than 20 per cent of the coal delivered to any date during the life of this contract shall contain 3 per cent more moisture, or 2 per cent more ash, or 3 per cent more volatile matter, or 1 per cent more sulphur, or 2 per cent fewer British thermal units than the specified guaranties as to the standards for the coal hereunder contracted for, or if coal is furnished from a mine or from mines other than herein specified, unless upon the written permission of the Government, then this contract may, at the option of the Government, be terminated, or the Government may, at its option, purchase coal in the open market until it may become satisfied that the contractor can furnish coal equal to the standards guaranteed, and the Government shall have the right to charge against the contractor any excess in price of coal so purchased over the corrected price that would have been paid to the contractor had the coal been delivered by him.

Removal of rejected coal.

31. The contractor shall be required to remove, without cost to the Government, within 48 hours after notification, coal that has been rejected by the Government. Should the contractor not remove rejected coal within the said 48 hours, the Government shall then be at liberty to have the said coal removed from its premises and to dispose of such coal by sale, as the Government shall elect. The proceeds from such sale, less all costs incidental to its removal and to the sale, shall be paid over to the contractor.

PRICE AND PAYMENT.

Determination of price.

32. The Government hereby agrees to pay the contractor within thirty (30) days after the completion of an order or delivery for each ton of 2,000 pounds of coal delivered and accepted in accordance with all the terms of this contract, the price per ton determined by taking the analysis of the sample, or the average of the analyses of the samples if more than one sample is analyzed, collected from the coal delivered upon the basis of the price herein named, adjusted as follows for variations in heating value, ash content, and moisture content from the standards guaranteed herein by the contractor. (See paragraph 13 in appendix for exception to this method:)

Heat unit adjustment.

(*a*) Considering the coal on a "dry-coal" basis, no adjustment in price shall be made for variations of 2 per cent or less in the number of British thermal units from the guaranteed standard. When the variation in heat units exceeds 2 per cent of the guaranteed standard, the adjustment shall be proportional and shall be determined by the following formula:

$$\frac{\text{B. t. u. delivered coal ("dry-coal" basis)}}{\text{B. t. u. ("dry-coal" basis) specified in contract}} \times \text{bid price} = \text{price resulting for B. t. u. variation from the standard.}$$

The adjusted price shall be figured to the nearest tenth of a cent.

As an example, for coal delivered on a contract guaranteeing 14,000 British thermal units on a "dry-coal" basis at a bid price of $3 per ton, showing by calorific test results varying between 13,720 and 14,280 British thermal units, there would be no price adjustment. If, however, by way of further example the delivered coal shows by calorific test 14,350 British thermal units on a "dry-coal" basis, the price for this variation from the contract guaranty would be, by substitution in the formula:

$$\frac{14{,}350}{14{,}000} \times \$3 = \$3.075$$

Ash adjustment.

(*b*) No adjustment in price shall be made for variations of 2 per cent or less below or above the guaranteed percentage of ash on the "dry-coal" basis. When the variation exceeds 2 per cent, the adjustment in price shall be determined as follows:

The difference between the ash content by analysis and the ash content guaranteed shall be divided by 2 and the quotient shall be multiplied by the bid price, and the result shall be added to or deducted from the B. t. u. adjusted price or the bid price, if there is no B. t. u. adjustment, according to whether the ash content by analysis is below or above the percentage guaranteed. The adjustment for ash content shall be figured to the nearest tenth of a cent.

As an example of the method of determining the adjustment in cents per ton for coal containing an ash content varying by more than 2 per cent from the standard, consider that coal for which the above-mentioned heat unit adjustment is to be made has been delivered on a contract guaranteeing 10 per cent ash, and shows by analysis an ash content of 7.50 per cent. The adjustment in price would be determined as follows:

The difference between 10 and 7.50, which is 2.50, would be divided by 2, and the quotient of 1.25 multiplied by $3, resulting in an adjust-

ment of 3.7 cents per ton, which in this case would be an addition. The price after adjustment for the variations in heating value and ash content would be $3.075 plus $0.037, or $3.112.

Moisture adjustment.

(*c*) The price shall be further adjusted for moisture content in excess of the amount guaranteed by the contractor, the deduction being determined by multiplying the price bid by the percentage of moisture in excess of the amount guaranteed. The deduction shall be figured to the nearest tenth of a cent.

As an example, consider that coal for which the above-mentioned heat unit and ash adjustments are to be made, and as having been delivered on a contract guaranteeing 3 per cent moisture, and that the coal shows by analysis 4.50 per cent moisture; then the bid price would be multiplied by 1.50 (representing excess moisture), giving 4.5 cents as the deduction per ton. The price to be paid per ton for the coal would then be $3.112, less $0.045, or $3.067.

Partial payment.

33. If coal on visual inspection by the Government inspector appears to be acceptable coal, the Government shall have the right, immediately on the completion of an order, to make payment on 90 per cent of the amount of the bill, based on the tonnage delivered and the bid price per ton. The 10 per cent withheld is to cover any deduction on account of the delivery of coal that on analysis and test is subject to an adjustment in price. If the 10 per cent withheld should not be sufficient to cover the deduction, then the amount due the Government may be taken from any money thereafter to become due to the contractor, or may be collected from the sureties. Because of the distance of the point of delivery from the laboratory, requiring several days for the transmittal of samples and the return of analytical report, because of loss of the original sample, necessitating the forwarding of the reserve sample, or for any other reason that would result in delayed payment, should such be withheld until receipt of analytical report, the Government may, as circumstances in its opinion warrant, exercise the foregoing right.

IX. ANTHRACITE COAL—DOMESTIC SIZES.

DESCRIPTION OF COAL DESIRED.

Character and quality.

34. The coal must be best quality, fresh-mined, anthracite, and it must be well screened, practically free from dirt, must not contain undue percentages of moisture, slate, or bone, or of coal of smaller sizes, and must equal in quality and preparation the best anthracite coal produced.

Information to be supplied by bidder.

35. The bidder shall be required to give the trade name of the coal offered, the name or other designation of coal bed or beds, the name of mine or mines producing the coal, location of mine or mines (town, county, and State), the name and address of the operator of mine or mines, and the railroad upon which the mine or mines are located, this information to be given in spaces provided hereinafter.

AWARD.

Considerations.

36. In determining the award of the contract, consideration shall be given to the results obtained with coals furnished on previous Government contracts by the respective bidders, as well as to the price per ton.

CAUSES FOR REJECTION.

Unsatisfactory coal.

37. If the percentage of bone, dirt, slate, or smaller sizes in a delivery exceeds the percentage required by the best preparation, or if the given coal fails to give satisfactory results because of excessive clinkering or excessive ash-pit refuse, it shall be subject to rejection, and payment may not be made for the remaining coal, and the Government shall have the right to cause the contractor to remove such coal at no cost to the Government. The Government may then purchase coal in the open market and make charge against the contractor for the excess in cost of coal so purchased.

Ash deductions.

38. If it is impracticable for the Government to cause the contractor to remove coal that produces excessive ash-pit refuse, samples may be taken during the consumption of such coal, provided not more than 50 per cent of the delivery had been consumed, and if on analysis the ash content on the "dry-coal" basis is equal to or greater than the following percentages for the respective sizes of coal, ten (10) per cent of the price of the delivery in question shall be deducted from any money due or that may thereafter be due the contractor:

Size of coal.	Ash in "dry coal," per cent.
Furnace	14
Egg	15
Stove	16
Chestnut	18

Unacceptable coal.

39. The Government inspector will not accept coal if, in his opinion, on visual inspection, it is subject to rejection, or if it contains an undue percentage of moisture, and he shall have the right to refuse to accept coal from a source other than that specified by the bidder, unless the contractor shall have received permission from the Government to substitute said coal.

Cancellation of contract.

40. If the contractor furnishes coal in three consecutive deliveries, or in case 20 per cent of the amount of the coal delivered to any date during the life of the contract is, in the opinion of the Government, subject to rejection, then the contract may, at the option of the Government, be terminated by written notice to the contractor to that effect.

PRICE AND PAYMENT.

41. Payment shall be made within thirty (30) days after the completion of an order and shall be based on the contract price, provided the coal is not subject to rejection.

X. INFORMATION TO BE SUPPLIED BY BIDDERS.

42. The following spaces should be filled in by the bidder for each bid, for if the information called for is not supplied, the proposal may be regarded as informal.

(Bidders are cautioned against specifying higher standards than can be maintained, for to do so may result in the bid being rejected, or may result in rejection of delivered coal or cancellation of the contract and the Government purchasing coal in the open market and charging against the contractor the difference in cost. See paragraphs 8, 29, 30, 31.)

.....

(To be signed by office issuing proposals.

.....

The undersigned agree.. to furnish to the ....., the coal described below, in tons of 2,000 pounds each, and in quantity as may be required during the fiscal year ending June 30, 191.., in accordance with the foregoing specifications; the coal to be delivered in such quantities and at such times as the Government may direct.

(*a*) Kind and size of coal.....
(*b*) Commercial name of coal.....
(*c*) Name of mine or mines.....
(*d*) Location of mine or mines (town, county, and State).....
.....
(*e*) Name or other designation of coal bed or beds.....
.....
(*f*) Railroad on which mine or mines are located.....
.....
(*g*) Name of operator of mine or mines.....
(*h*) Percentage of moisture in coal "as received".....
(*i*) Percentage of ash in "dry coal".....
(*j*) Percentage of volatile matter in "dry coal".....
(*k*) Percentage of sulphur in "dry coal".....
(*l*) British thermal units per pound of "dry coal".....
(*m*) Additional description of coal deemed of importance by the bidder.....
.....

(*n*) Price per ton of 2,000 pounds for delivery (for bituminous coal and for pea and buckwheat sizes of anthracite this price is understood to be the bid price per ton, see paragraph 32 for method of determining price for delivered coal).....

NOTE.—The information called for under *h*, *i*, *j*, *k*, and *l* is not required for bids on the domestic sizes of anthracite coal; that is, furnace, egg, stove, and chestnut.

The undersigned ha.. read the specifications and proposals and agree.. to comply therewith in every particular.

.....

Signature of each member of the firm and firm name. If a corporation, its name and signature of the officer authorized to sign for the corporation, together with a copy, under seal of his authority, to sign; also the name of the State in which incorporated.

.....
.....
.....

Doing business under the firm name of.....
Place of business.....
Date.....

NOTE.—Owing to the difficulty in deciphering signatures, a typewritten copy of same should be attached.

APPENDIX A.

METHOD OF SAMPLING COAL DELIVERIES.

(To be attached to and to become a part of the Specifications and Proposals issued by the Office of the ....., for the purchase of coal for the fiscal year commencing July 1, 191.., and ending June 30, 191...)

NOTE.—As payment for bituminous and the steam sizes of anthracite coal is to be based upon the quality as shown by analyses of representative samples, it is imperative that every sample be collected and prepared carefully and conscientiously and in strict accordance with the method agreed upon herein, for if the sampling is improperly done, a determined price based on the analysis will be in error and it may be impossible or impracticable to take another sample: but if an analysis is in error, another analysis can easily be made of the original sample.

Gross samples of the quantities designated herein must be taken whether the delivery consists of a few tons or several hundred tons, because of the following cardinal principle in sampling coal that must be recognized and understood; that is, the effect of the chance inclusion or exclusion of too many or too few pieces of slate, or other impurities in what, or from what, would otherwise have been a representative sample will cause the analysis to be in error accordingly, regardless of the tonnage sampled. For example, the chance inclusion or exclusion of 10 pounds too much or too little of impurities in or from an otherwise representative sample of 100 pounds would cause the analysis to show an error in ash content and heating value of approximately 10 per cent, whereas for a 1,000-pound sample, the effect would be approximately only 1 per cent, the effect being the same whether the sample is collected from a 1-ton lot or from a lot consisting of several hundred tons.

Time of sampling.

1. The coal shall be sampled when it is being loaded into or unloaded from railroad cars, ships, barges, or wagons, or when discharged from supply bins, or from industrial railway cars, or grab buckets, or from the coal-conveying equipment, as the case may be and as may be mutually agreed upon. If the coal is crushed as received, samples usually can be taken advantageously after the coal has passed through the crusher. Samples collected from the surface of coal in piles or bins, or in cars, ships, or barges, are generally unreliable.

Size of increments.

2. To collect samples, a shovel or specially designed tool or mechanical means shall be used for taking equal portions or increments. For slack or small sizes of anthracite, increments as small as 5 to 10 pounds may be taken, but for run-of-mine or lump coal the increments should be at least 10 to 30 pounds.

Collection of gross sample.

3. The increments shall be regularly and systematically collected, so that the entire quantity of coal sampled will be represented proportionately in the gross sample, and with such frequency that a gross sample of the required amount shall be collected. The standard gross sample shall not be less than 1,000 pounds, except that for slack coal and small sizes of anthracite in which the impurities do not exist in abnormal quantities or in pieces larger than ¾ inch, a gross sample of approximately 500 pounds shall be considered sufficient. If the coal contains an unusual amount of impurities, such as slate, and if the pieces of such impurities are very large, a gross sample of 1,500 pounds or more shall be collected. The gross sample should contain the same proportion of lump coal, fine coal, and impurities as is contained in

the coal sampled. When coal is extremely lumpy it is best to break a proportional amount of the lumps before taking the various increments of a sample. Provision should be made for the preservation of the integrity of the sample.

Quantity represented.

4. A gross sample shall be taken for each 500 tons or less, or in case of larger tonnages for such quantities as may be agreed upon.

Preparation.

5. After the gross sample has been collected, it shall be systematically crushed, mixed, and reduced in quantity to convenient size for transmittal to the laboratory. The sample may be crushed by hand or by any mechanical means, but under such conditions as shall prevent loss or the accidental admixture of foreign matter. Samples of the quantities indicated in Table 1 following shall be so crushed that no pieces of coal and impurities will be not greater in any dimension, as judged by the eye, than specified for the sample before division into two approximately equal parts.

TABLE 1.—*Largest sizes of coal and impurities allowable in samples ranging from 1,000 to 30 pounds in weight.*

Weight of sample to be divided, pounds.	Largest size of coal and impurities allowable in sample before division.
1,000 or more	1 inch.
500	$\frac{3}{4}$ inch.
250	$\frac{1}{2}$ inch.
125	$\frac{3}{8}$ inch.
60	$\frac{1}{4}$ inch.
30	$\frac{3}{16}$ inch, or 4-mesh screen.

The method of reducing by hand the quantity of coal in a gross sample shall be carried out as prescribed below, even should the initial size of the coal and impurities be less than Table 1.

Hand preparation.

6. The progressive reduction in the weight of the sample to the quantities indicated in Table 1 shall be done by the following methods, which are shown in the accompanying illustration (Pl. V):

Mixing and reduction by discarding alternate shovelfuls.

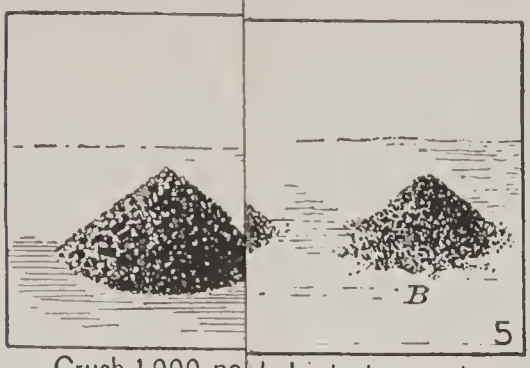
(*a*) The alternate-shovel method of reducing the gross sample shall be repeated until the sample is reduced to approximately 250 pounds; and care shall be observed before each reduction in quantity that the sample has been crushed to the fineness prescribed in Table 1.

The crushed coal shall be shoveled into a conical pile (figs. 2 and 7) by depositing each shovelful of coal on top of the preceding one, and then formed into a long pile in the following manner:

The sampler shall take a shovelful of coal from the conical pile and spread it out in a straight line (figs. 3, *A*, and 8, *A*) having a width equal to the width of the shovel and a length of 5 to 10 feet. His next shovelful shall be spread directly over the top of the first shovelful, but in the opposite direction, and so on back and forth, the pile being occasionally flattened until all the coal has been formed into one long pile (figs. 3, *B*, and 8, *B*). The sampler shall then discard half of this pile, proceeding as follows:

Beginning on one side of the pile, at either end, and shoveling from the bottom of the pile, the sampler shall take one shovelful (shovelful No. 1, figs. 4 and 9) and set it aside; advancing along the side of the pile a distance equal to the width of the shovel, he shall take a second shoveful (shovelful No. 2, figs. 4 and 9) and discard it; again advancing

First stage in the preparation of 1,000-pound sample.

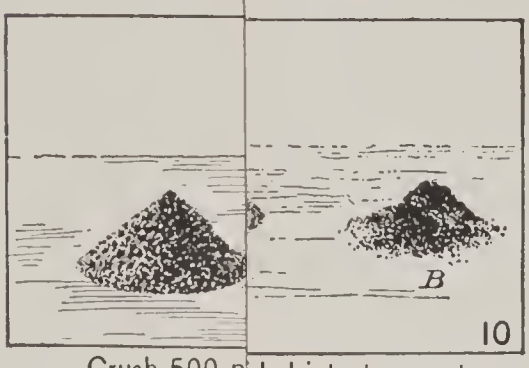


Crush 1,000-po ded into two parts; hard, clean surf rve; B—reject

NOTE

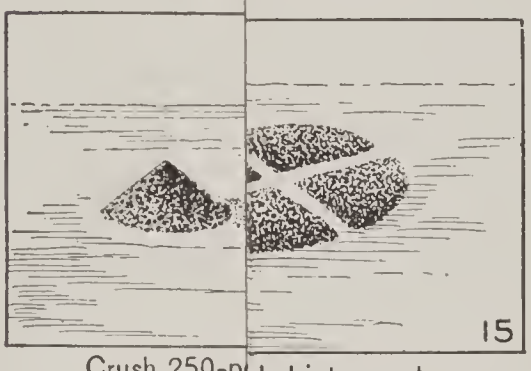
SELECT A HARD, CLEAN SURFACE, FREE OF CRACKS AND PROTECTED FROM RAIN, SNOW, WIND, AND BEATING SUN. DO NOT LET CINDERS, SAND, CHIPPINGS FROM FLOOR, OR ANY OTHER FOREIGN MATTER GET INTO THE SAMPLE. PROTECT SAMPLE FROM LOSS OR GAIN IN MOISTURE

Second stage.

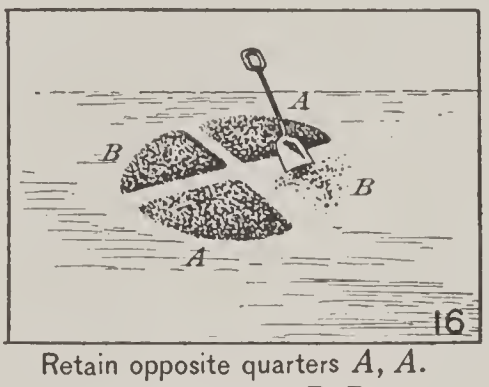


Crush 500-p ded into two parts; (fig. 5, A) rve; B—reject

Third stage.

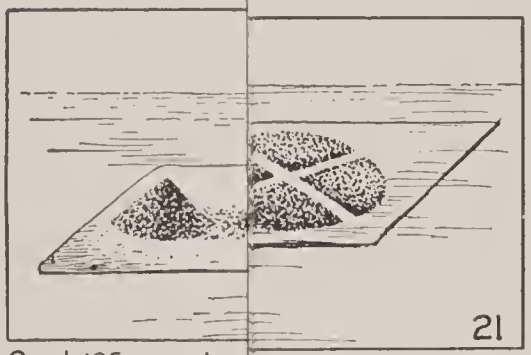


Crush 250-p ded into quarters (fig.10, A) t

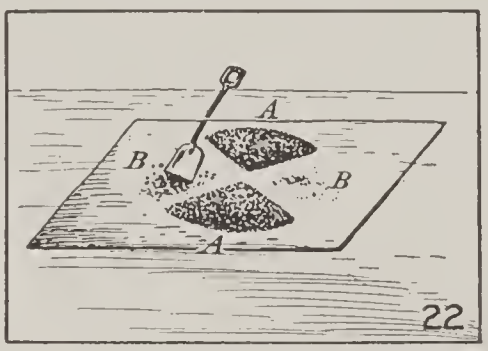


Retain opposite quarters A, A. Reject quarters B, B

Fourth stage.



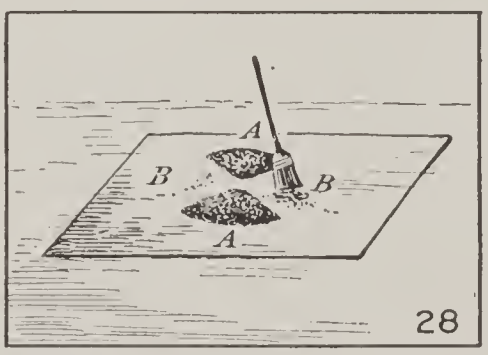
Crush 125-pound sa ded into quarters on blanket



Retain opposite quarters A, A. Reject quarters B, B

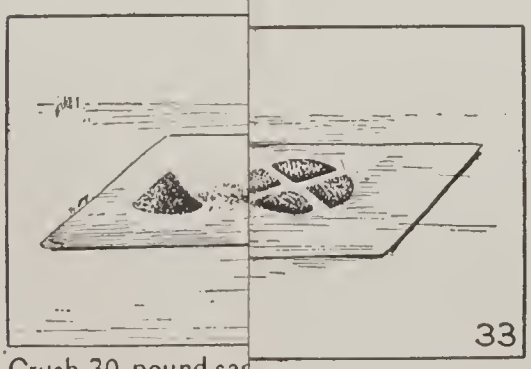
Fifth stage.

Crush 60-pound sa ded into quarters to ¼″

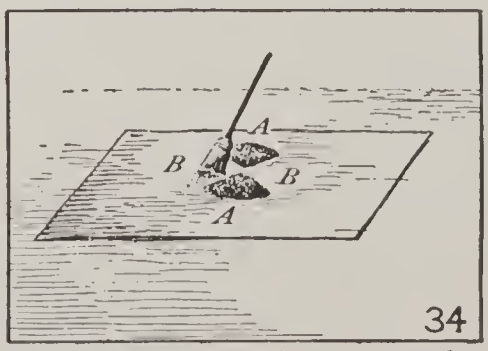


Retain opposite quarters A, A. Reject quarters B, B

Sixth stage.



Crush 30-pound sa ded into quarters to 3/16″ or 4



Fill two 5-pound sample containers from A, A, one for laboratory, one for reserve

METHOD O FEET, BROOM, AND RAKE. THE COAL IS RAKED W ER SAMPLE IS HALVED OR QUARTERED.

in the same direction one shovel width, he shall take a third shovelful (shovelful No. 3, figs. 4 and 9) and add it to the first. Shovelful No. 4 (figs. 4 and 9) is to be taken in a like manner and discarded, the fifth shovelful (No. 5, figs. 4 and 9) retained, and so on, the sampler advancing always in the same direction around the pile, so that its size will be gradually reduced in a uniform manner. When the pile is removed, about half of the original quantity of coal should be contained in the new pile formed by the alternate shovelfuls which have been retained (figs. 5, *A*, and 10, *A*, show the retained halves, and 5, *B*, and 10, *B*, the rejected halves).

Mixing and reduction by quartering.

(*b*) After the gross sample has been reduced by the above method to approximately 250 pounds, further reduction in quantity shall be by the quartering method. Before each quartering, the sample shall be crushed to the fineness prescribed in Table 1.

Quantities of 125 to 250 pounds shall be thoroughly mixed by coning and reconing (figs. 12 and 13); quantities less than 125 pounds shall be placed on a suitable cloth, measuring about 6 by 8 feet, mixed by raising first one end of the cloth and then the other (figs. 18, 24, and 30), so as to roll the coal back and forth, and after being thoroughly mixed shall be formed into a conical pile by gathering together the four corners of the cloth (figs. 19, 25, and 31). The quartering of the conical pile shall be done as follows:

The cone shall be flattened, its apex being pressed vertically down with a shovel or board, so that after the pile has been quartered each quarter will contain the material originally in it. The flattened mass, which shall be of uniform thickness and diameter, shall then be marked into quarters (figs. 14, 20, 26, and 32) by two lines that intersect at right angles directly under a point corresponding to the apex of the original cone. The diagonally opposite quarters (*B*, *B* in figs. 16, 22, 28, and 34) shall then be shoveled away and discarded and the space that they occupied brushed clean. The coal remaining shall be successively crushed, mixed, coned, and quartered until two opposite quarters shall equal approximately 10 pounds of $\frac{3}{16}$-inch or 4-mesh size. This 10-pound quantity shall be divided into two equal parts and each part shall be placed in a container suitable for transportation and shall bear an unbroken seal. One of the samples shall be forwarded by the officer in charge to the Bureau of Mines, Department of the Interior, for analysis, and the other shall be held in reserve by the officer in charge. Should the sample forwarded be lost or damaged in transit, then the reserve sample shall be forwarded.

Mechanical preparation.

7. Only such mechanical means as will give equally representative samples shall be used in substitution for the hand method of preparation herein specified.

Extended deliveries.

8. For convenience, or if the accumulation of a sample would extend over any considerable period of time, the several quantities that would otherwise be combined to make up the gross sample may be worked down as collected and reduced to samples of a size suitable for transmittal to the laboratory, and these fractional samples may be analyzed and the several analyses averaged, or the several samples may later be mixed at the place of sampling or in the laboratory and reduced to one sample, one analysis being made. In the averaging of analyses or in the mixing of the several samples, weights shall be used proportionate to the tonnages which the fractional samples represent.

Special moisture sample.

9. In the reduction of the gross sample to the sample for transmittal to the laboratory, the gross sample may unavoidably lose moisture. To determine the moisture content in the coal delivered, a separate special moisture sample may be taken. This special moisture sample shall be taken so as to represent the coal with respect to the moisture contained at the time of weighing.

Collection of moisture sample.

10. The special moisture sample shall weigh approximately 100 pounds, and shall be accumulated by placing in a waterproof receptacle with a tight-fitting and waterproof lid small equal parts of the freshly taken increments of the gross sample, or they may be collected separately and independently of the gross sample. The accumulated moisture sample shall be rapidly crushed and reduced mechanically or by hand to about a 5-pound quantity, which shall be immediately placed in a container and sealed air-tight and forwarded to the laboratory. If prepared by hand, it shall be rapidly crushed so that no pieces of coal or impurities are larger than one-half inch, and it shall be rapidly reduced by the quartering method on a cloth to the 5-pound quantity.

Moisture samples discretionary.

11. The collection of special moisture samples shall be discretionary with the Government. If special moisture samples are not taken, the moisture determined for the gross sample shall govern, provided the gross sample shall be taken so as to represent the coal with respect to the moisture contained at the time of weighing, otherwise the moisture determination shall be waived.

Moisture sample may represent any part of delivery.

12. A special moisture sample may be taken from any one railroad car or cars, or from a part of a delivery, if, in the opinion of the Government, said car or cars, or said part of a delivery contains moisture in excess of the amount guaranteed by the contractor, and should the moisture content of this special sample be in excess of the moisture content guaranteed by the contractor, then the Government shall have the right to make a deduction in price in accordance with paragraph 32 (*c*) under "Price and Payment," for the car or cars, or the part of the delivery sampled, and this correction shall in no wise affect the moisture correction for other railroad cars or parts of the delivery that may be sampled, or the correction that shall apply for variations of ash and heating value as determined for the delivery or order. The special moisture sample shall be used for no other purpose than for determining moisture content, and the moisture content so determined shall be considered as final.

Sampling of 50 tons or less discretionary.

13. When orders are issued for 50 tons or less, sampling shall be discretionary with the Government; and if samples are not taken, the bid price per ton shall be paid.

PUBLICATIONS ON FUEL TECHNOLOGY.

A limited supply of the following publications of the Bureau of Mines is temporarily available for free distribution. Requests for all publications can not be granted, and applicants should limit their selection to publications that may be of especial interest to them. Requests for publications should be addressed to the Director, Bureau of Mines, Washington, D. C.

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